Rob & Smith's

Operative Surgery

Ear

Fourth Edition

Edited by

John C. Ballantyne CBE, FRCS, HonFRCSI, DLO
Consultant Ear, Nose and Throat Surgeon, Royal Free and King Edward VII Hospital for Officers, London, UK

and

Andrew Morrison FRCS
Senior Surgeon, Ear, Nose and Throat Department, The London Hospital, London, UK

Butterworths
London Boston Durban Singapore Sydney Toronto Wellington

Contents

Illustrations by R. A. H. Neave

Lesions of the pinna

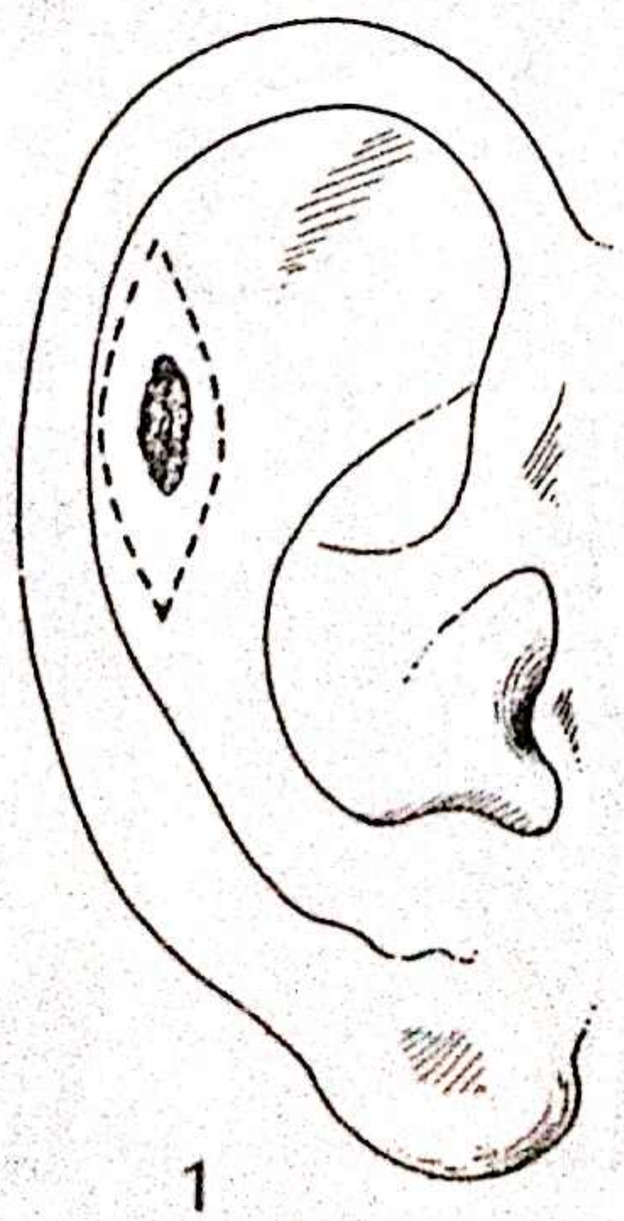
Clive Orton FRCS, FDS, RCS
Consultant Plastic Surgeon, University Hospital of South Manchester, Manchester, UK

BENIGN LESIONS

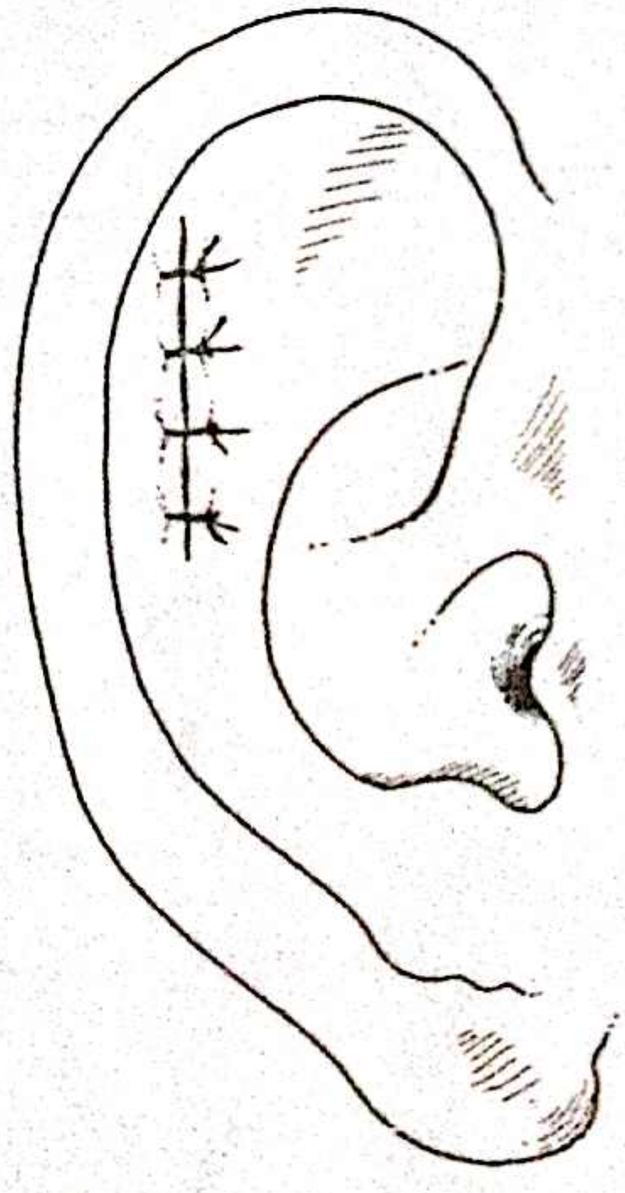
The operation

1 & 2

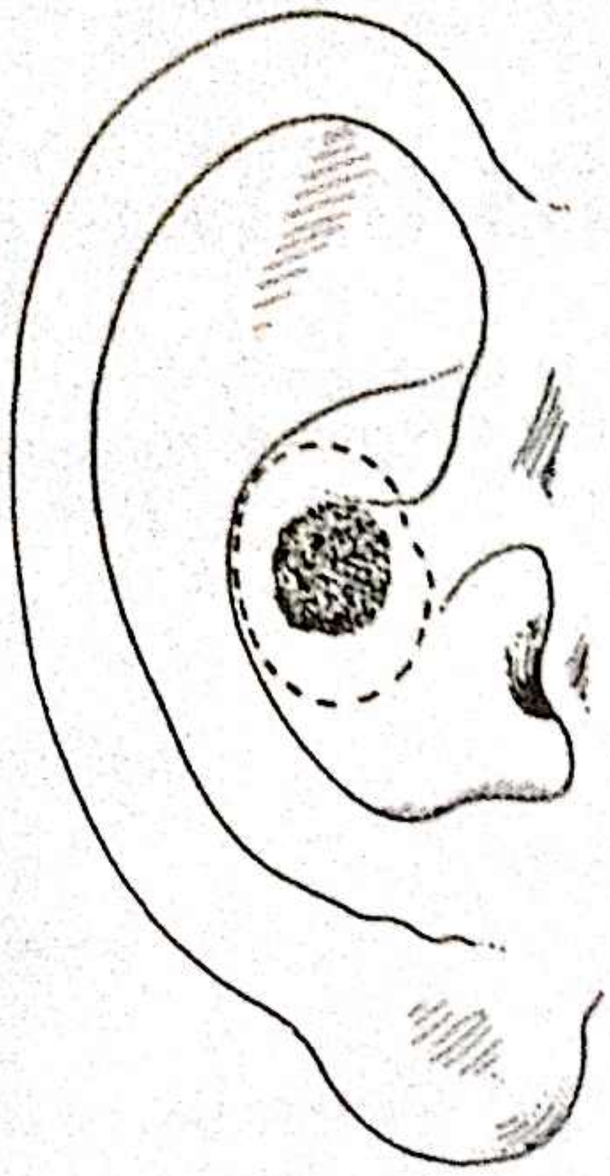
Benign lesions of the pinna may be excised and closed by direct suture where adequate soft tissue is present. Removal of a segment of underlying cartilage may enable closure without tension in some areas.



1



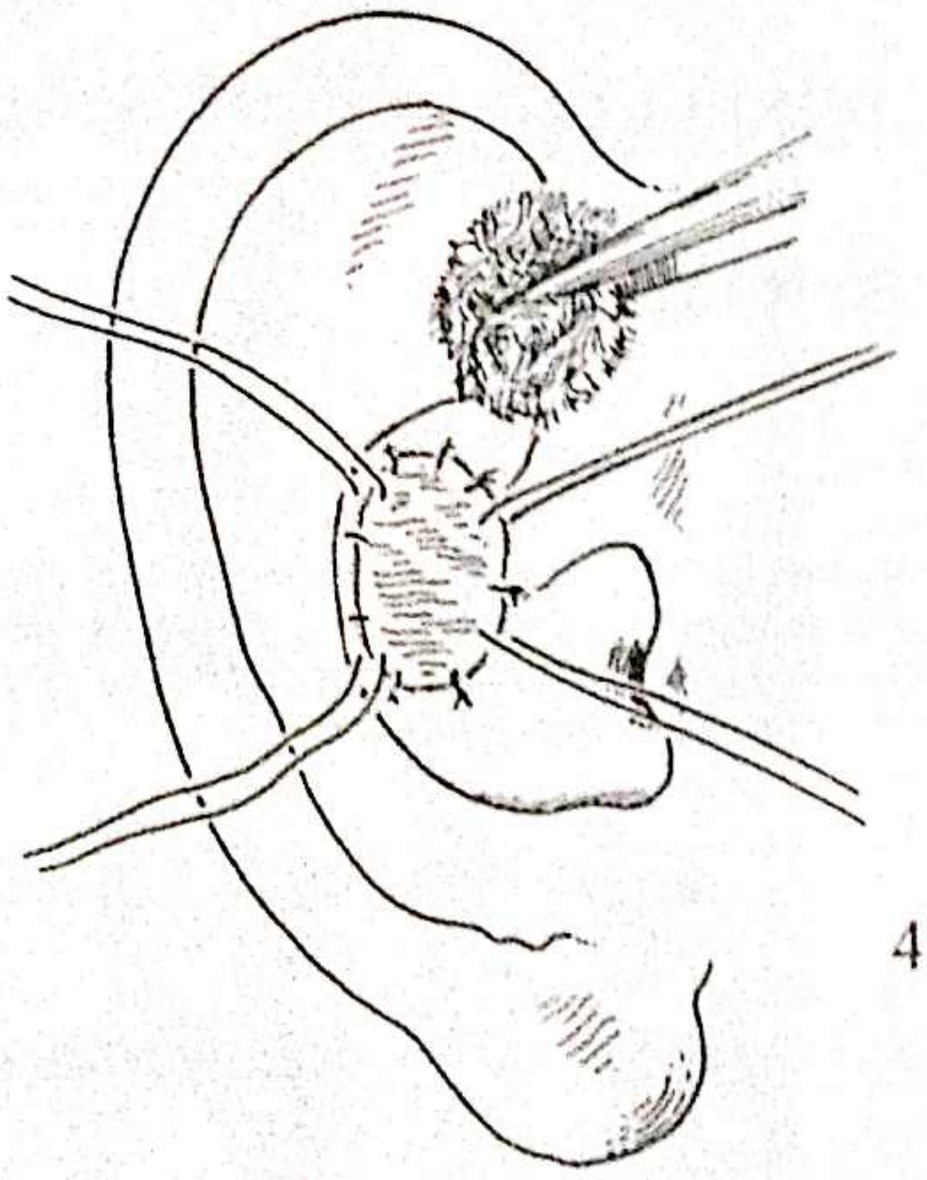
2



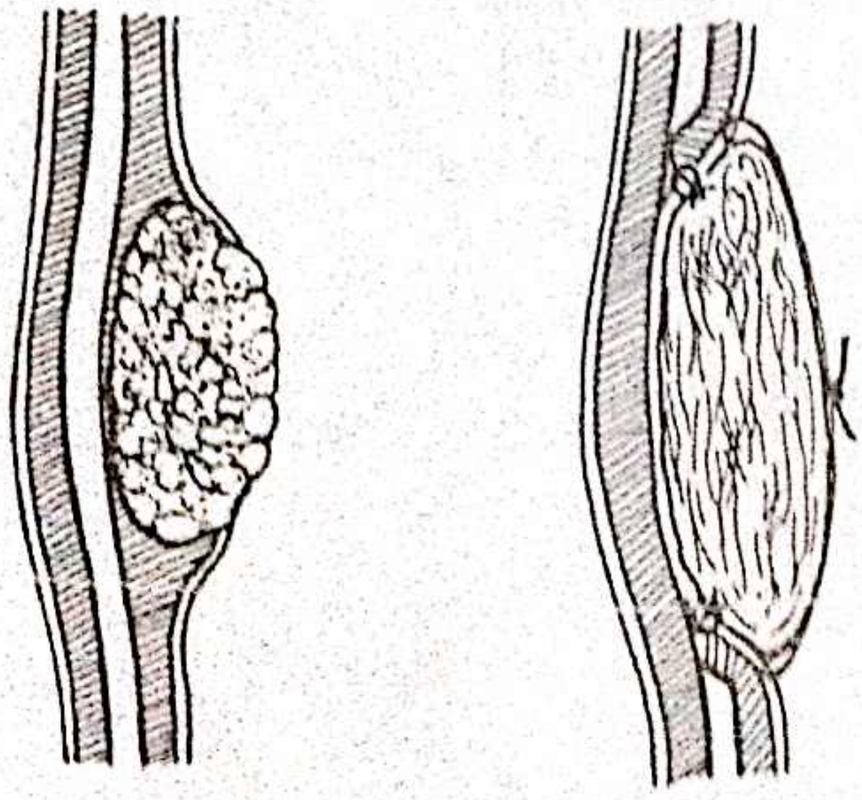
3

3, 4 & 5

Where direct closure is not feasible a skin graft may be applied to the underlying perichondrium and a tie-over dressing is required.



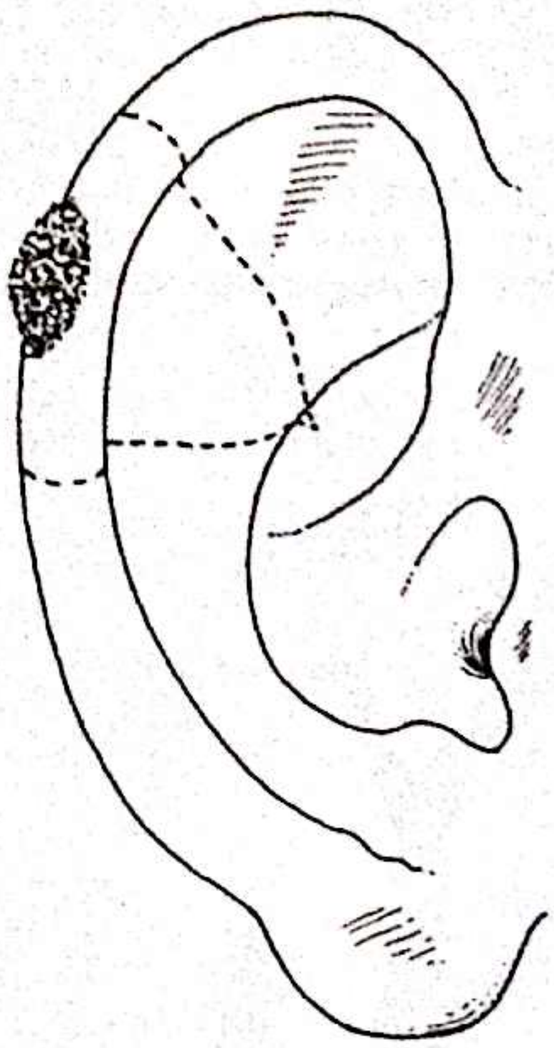
4



5

MALIGNANT LESIONS

The common malignant conditions of the pinna are squamous and basal cell carcinomas, and they must be differentiated from benign lesions such as keratoacanthoma and chondromalacia dolorens by biopsy.



6

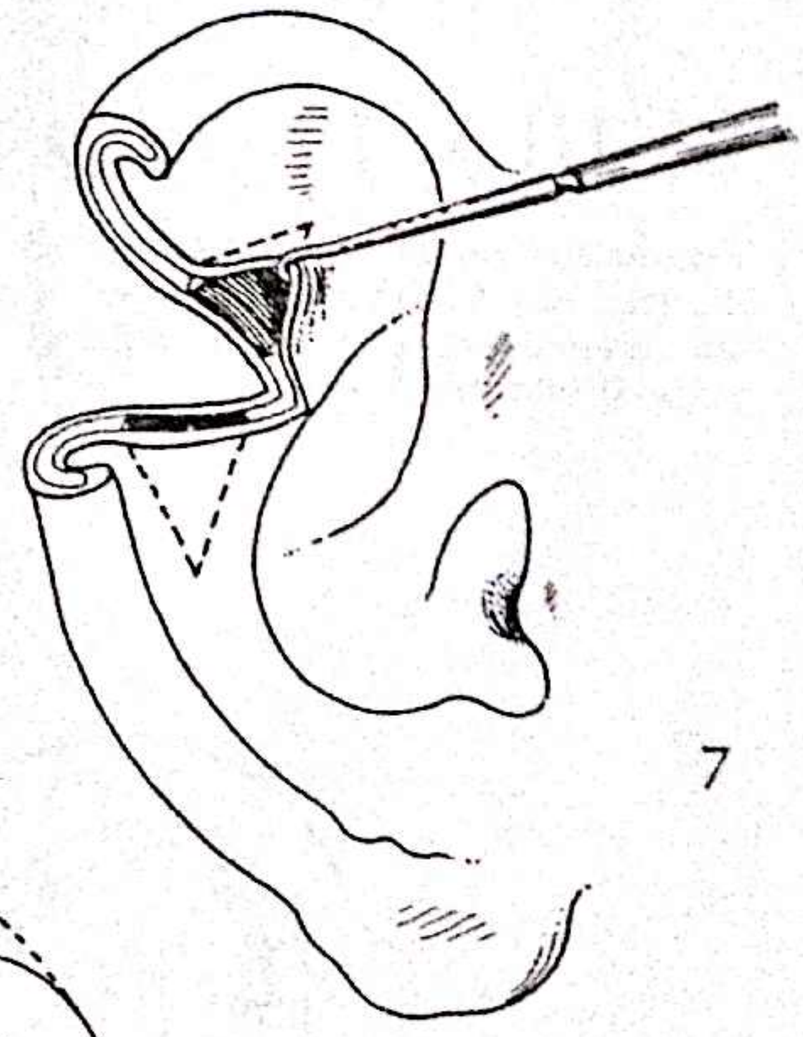
The operations

LOCAL EXCISION

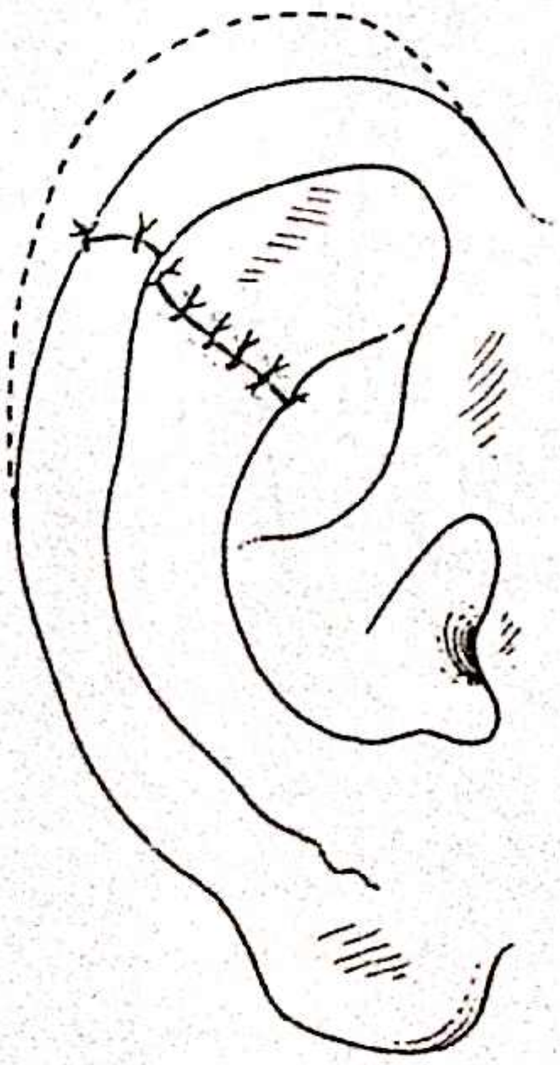
6, 7 & 8

For small and superficial tumours of low malignancy wedge excision of the pinna may be performed, taking a margin of clearance of 5–10 mm. Closure is then carried out in layers, suturing the cartilage after excision of horizontal wedges sufficient to avoid buckling of the ear.

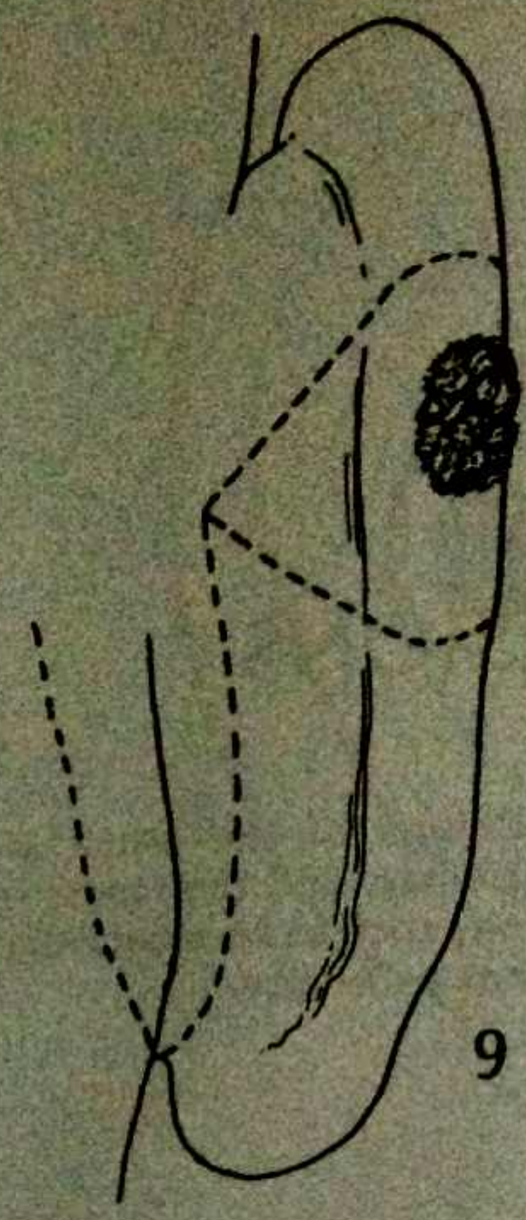
Where a long segment of the helical rim has been excised, direct closure cannot be achieved without causing a secondary shell ear deformity. It is then necessary to decide whether to perform a reconstruction or whether it is preferable to carry out a complete pinnectomy with or without subsequent prosthetic restoration.



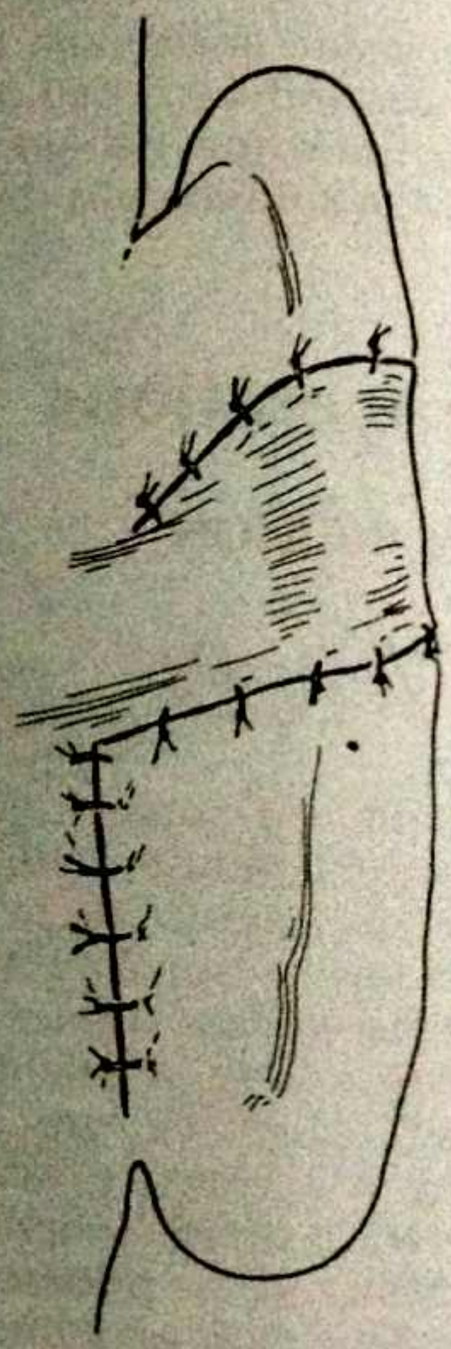
7



8



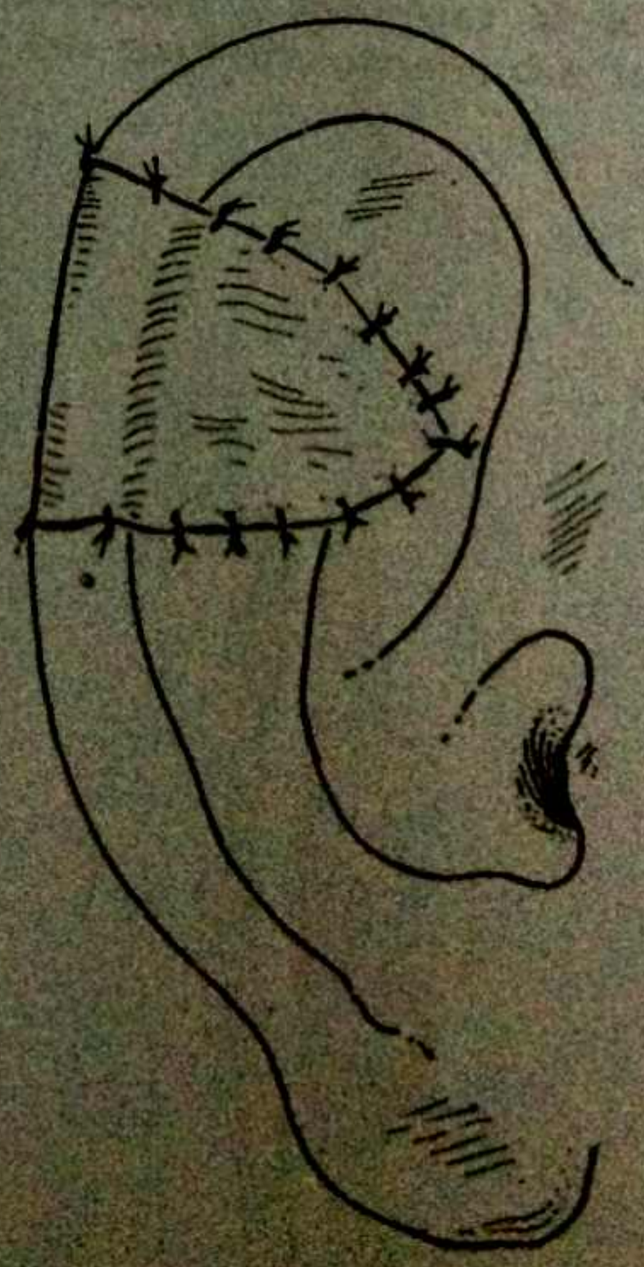
9



10

9, 10 & 11

Reconstruction of simple defects of this type may be carried out by transposition of a flap of skin and subcutaneous tissue taken from the postauricular fold and sutured into the defect.

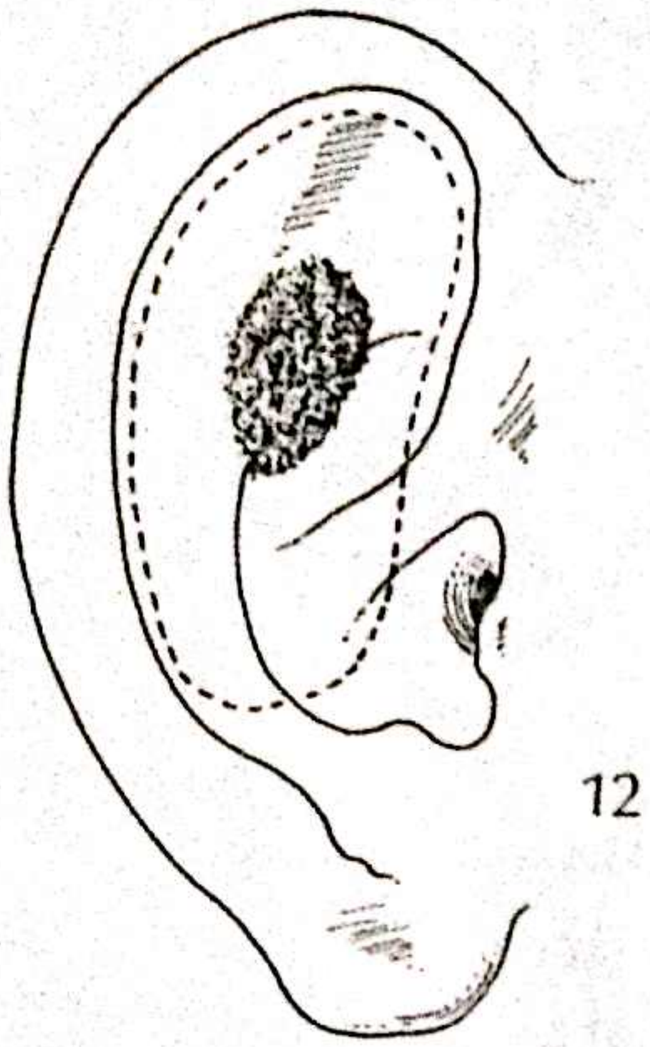


11

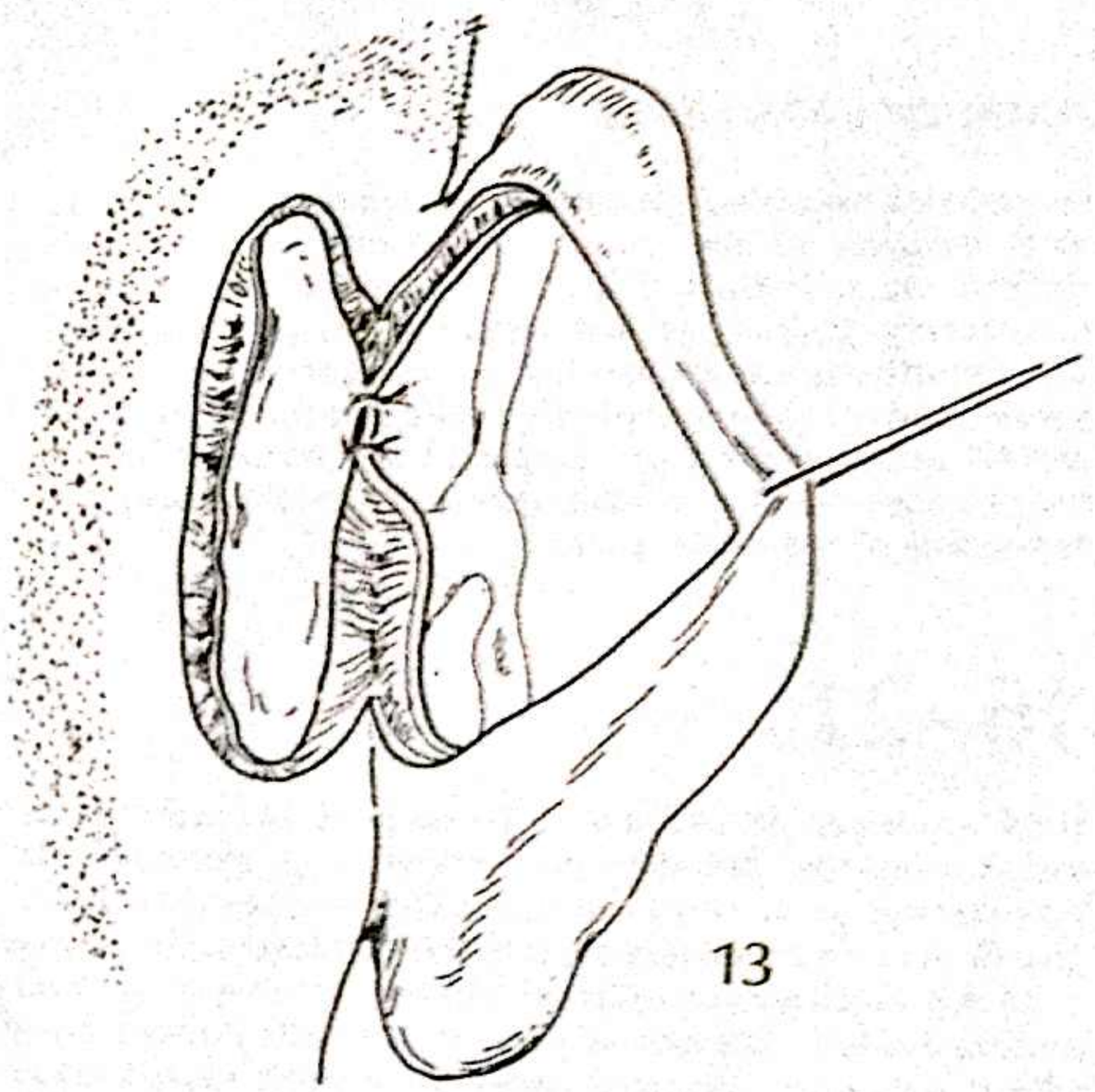
12–15

In cases where the tumour is situated centrally in the concha it may be possible to preserve the helix and excise the central portion of the pinna through all its layers. The helix may then be sutured directly to the mastoid skin after an incision to create a suitable raw area to receive it.

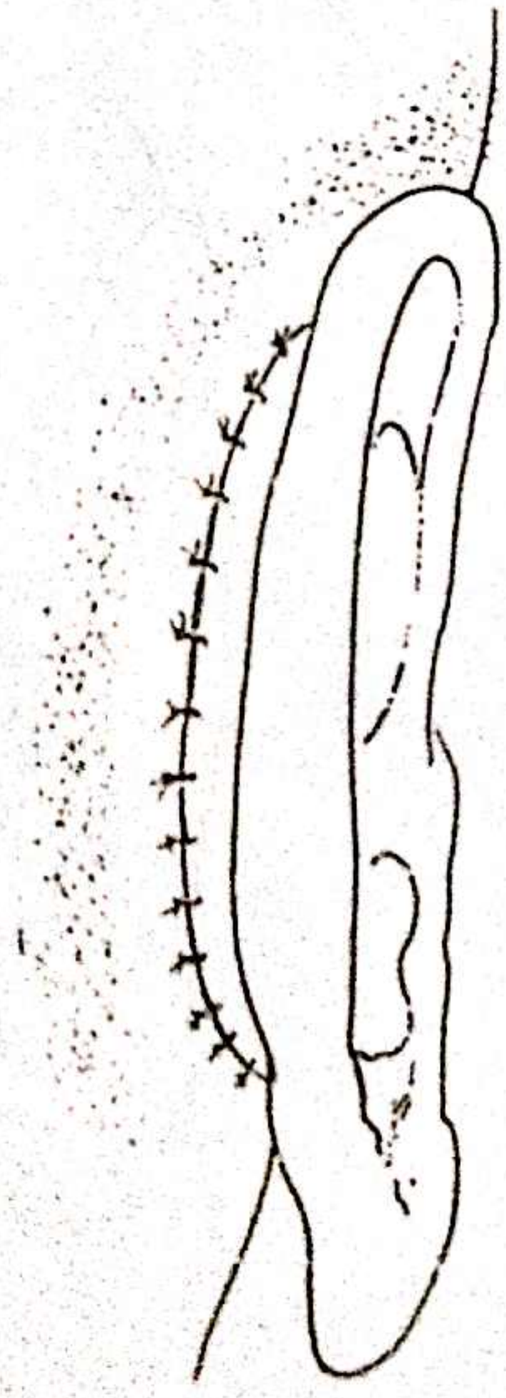
The absence of the normal conchal cavity will not be noticeable from the front and is inconspicuous from the side. Preservation of the helix must not jeopardize excisional margins for tumour control.



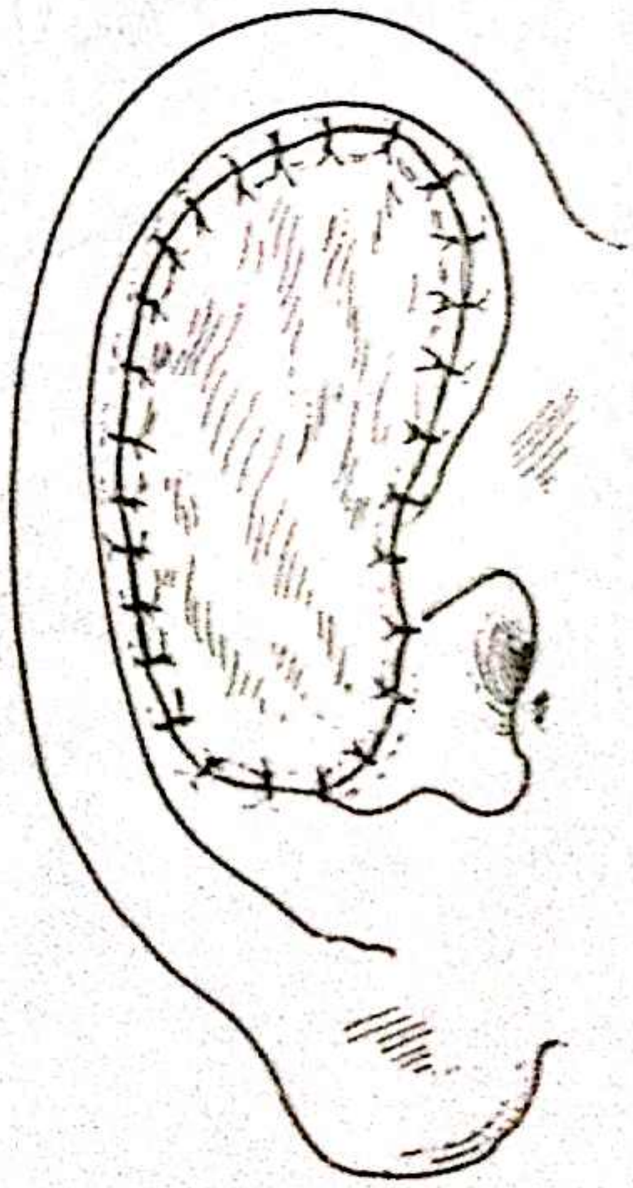
12



13



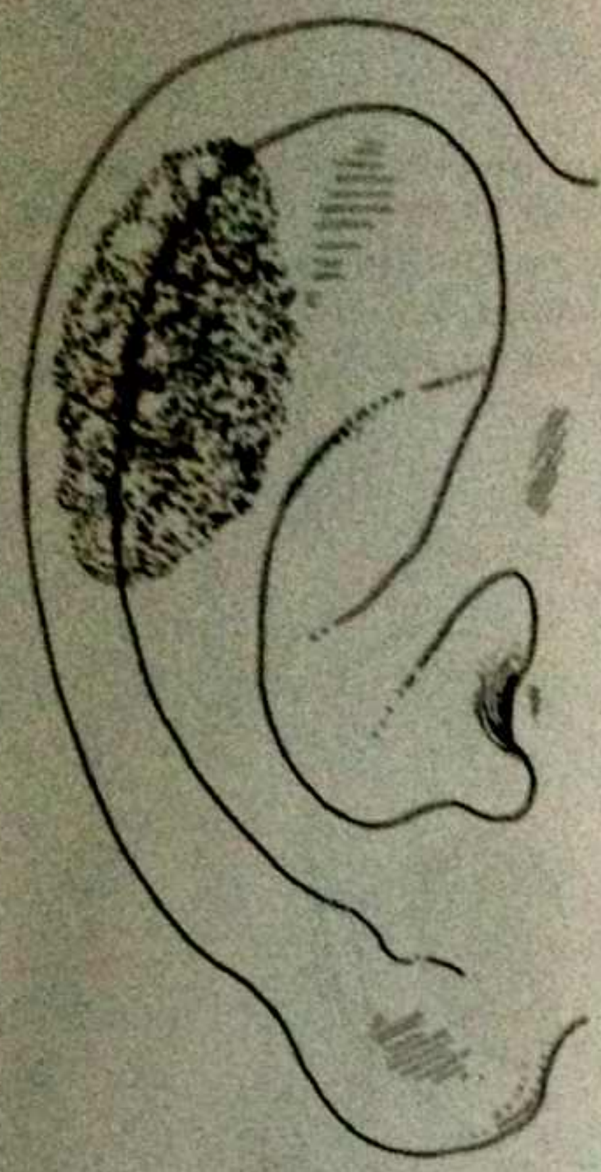
14



15

TOTAL EXCISION OF EAR

In patients requiring prosthetic replacement of the ear, total excision of the pinna is indicated because it is difficult to construct a partial ear prosthesis with a satisfactory appearance and secure adhesive properties. The exceptions are (1) females in whom an upper partial pinnectomy may be completely concealed by the hairstyle and (2) patients who wear spectacles, the frames of which may be supported by a small segment of cartilage and skin remaining at the upper pole.

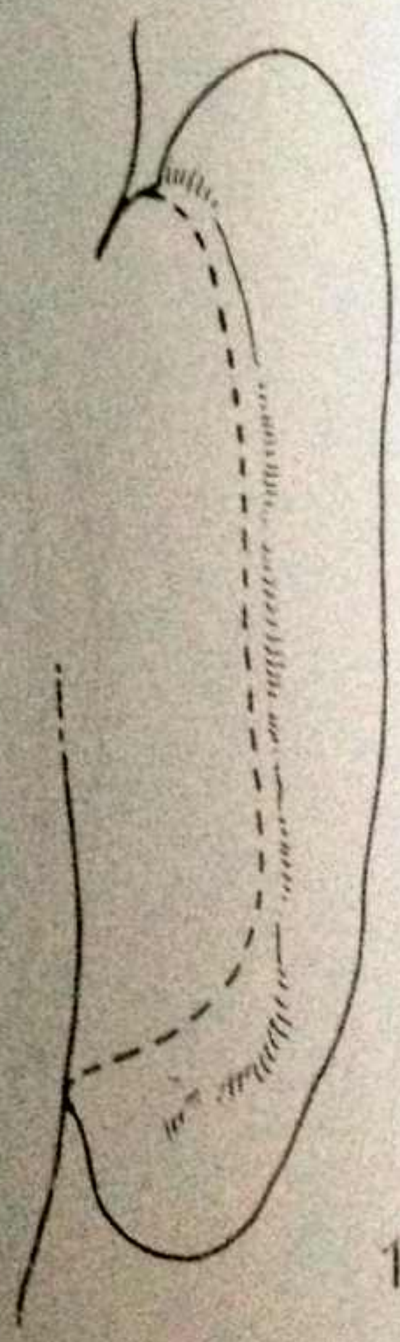


16

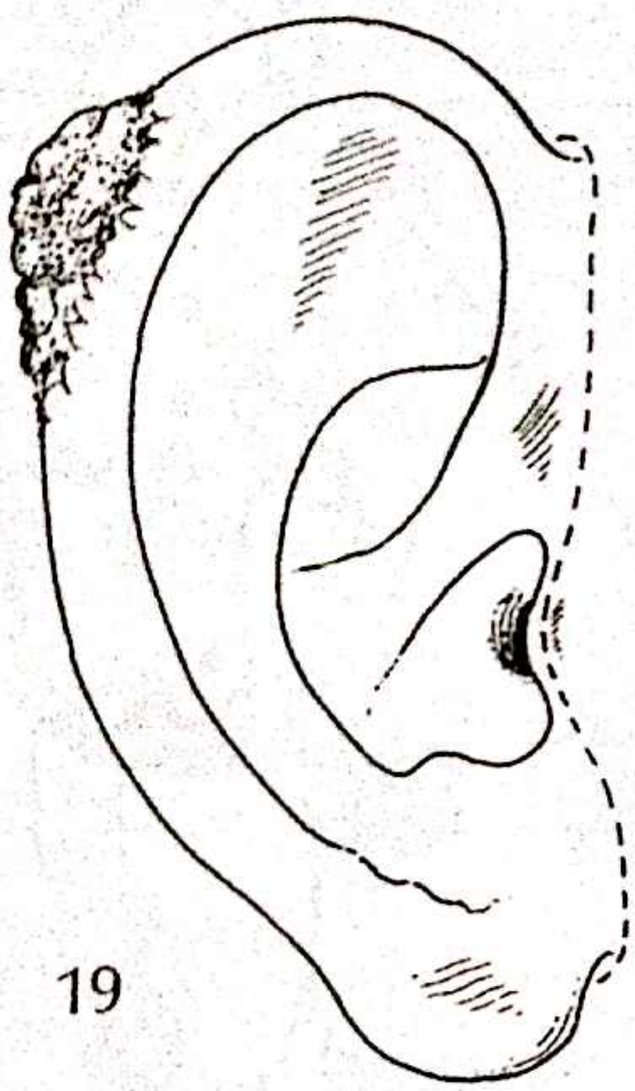
16–21

Total excision of the ear is performed by making an incision in the pre-auricular groove and extending it posteriorly, excising adequate skin for tumour clearance. The dissection continues deep to the cartilage of the pinna until the cartilaginous external auditory meatus is reached and transected. The wound may be closed by direct suture where adequate skin cover remains or by the application of a split skin graft to the periosteum overlying the mastoid process.

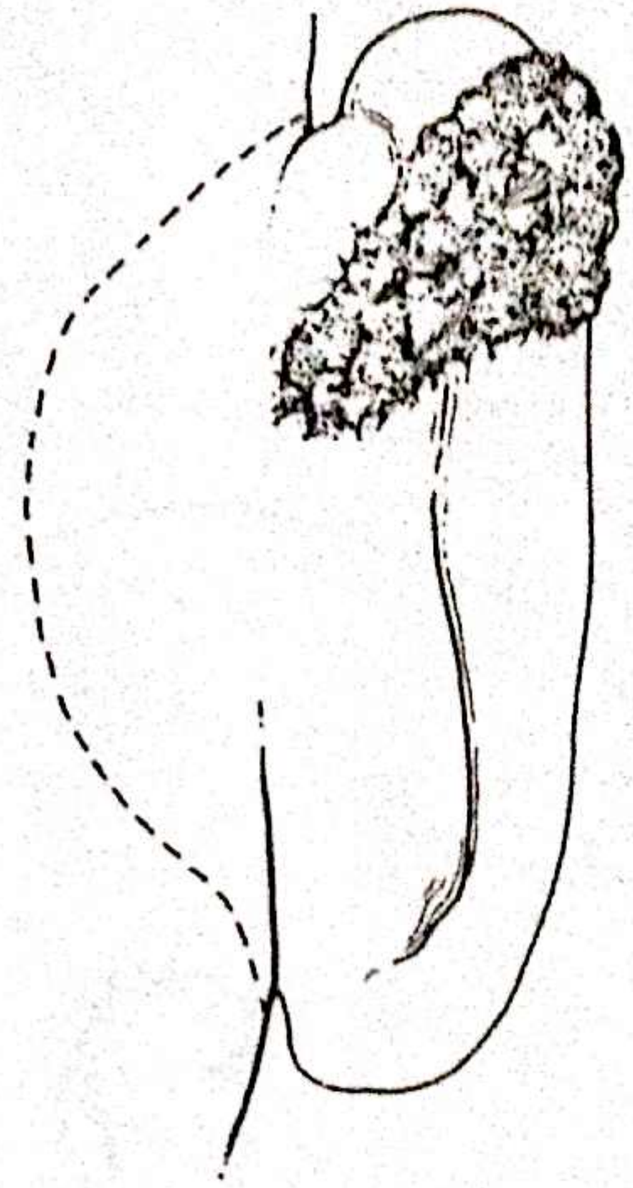
17



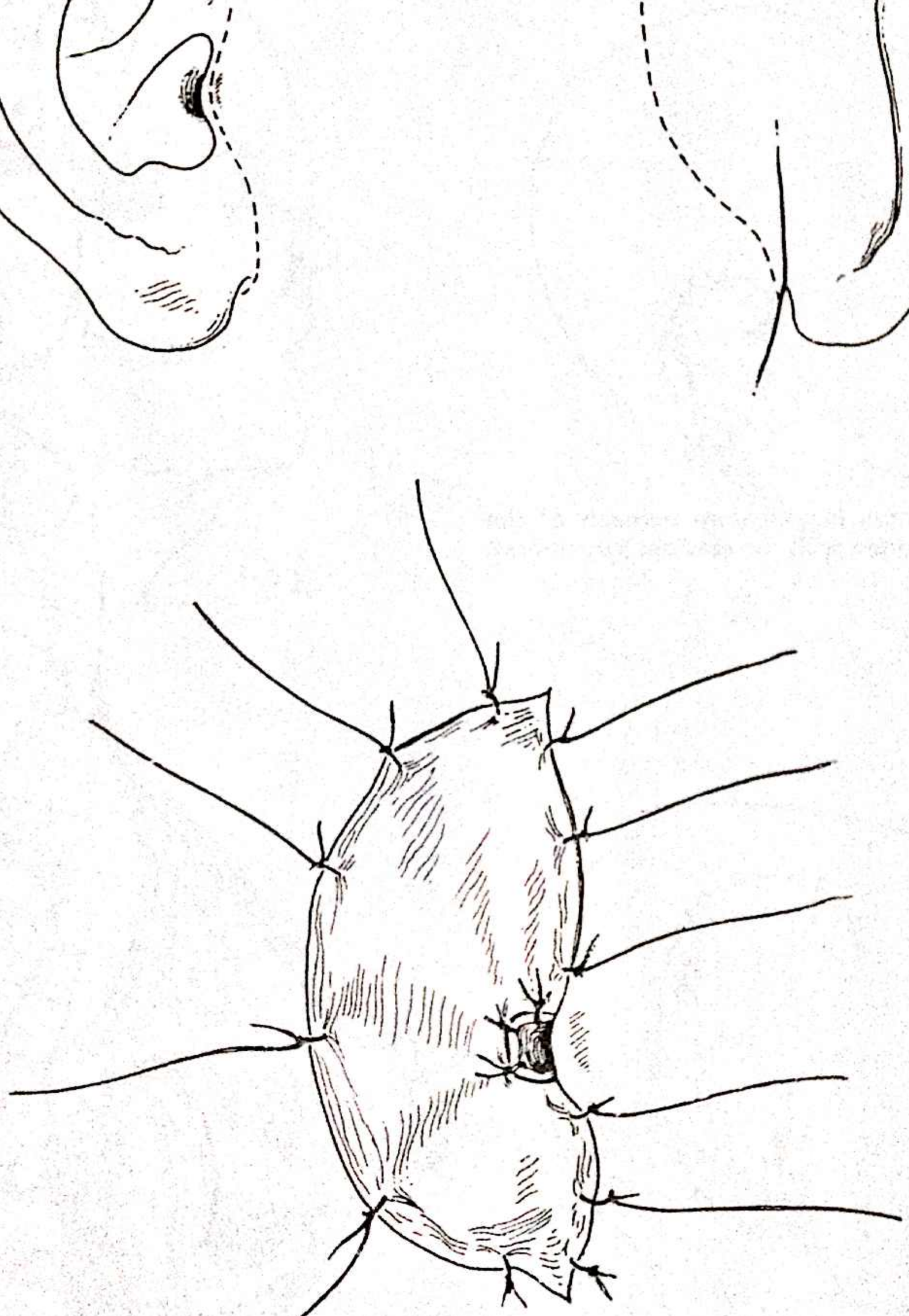
18



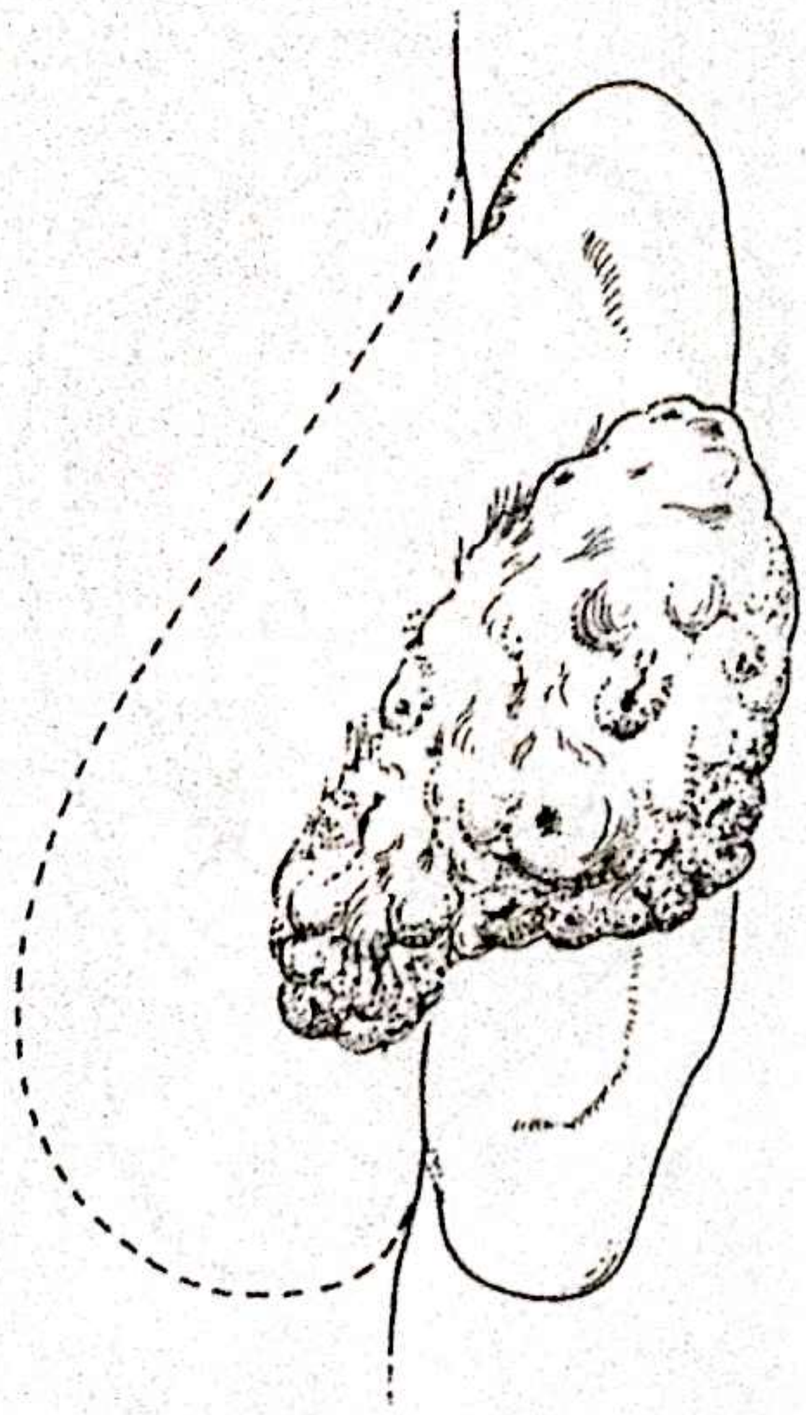
19



20



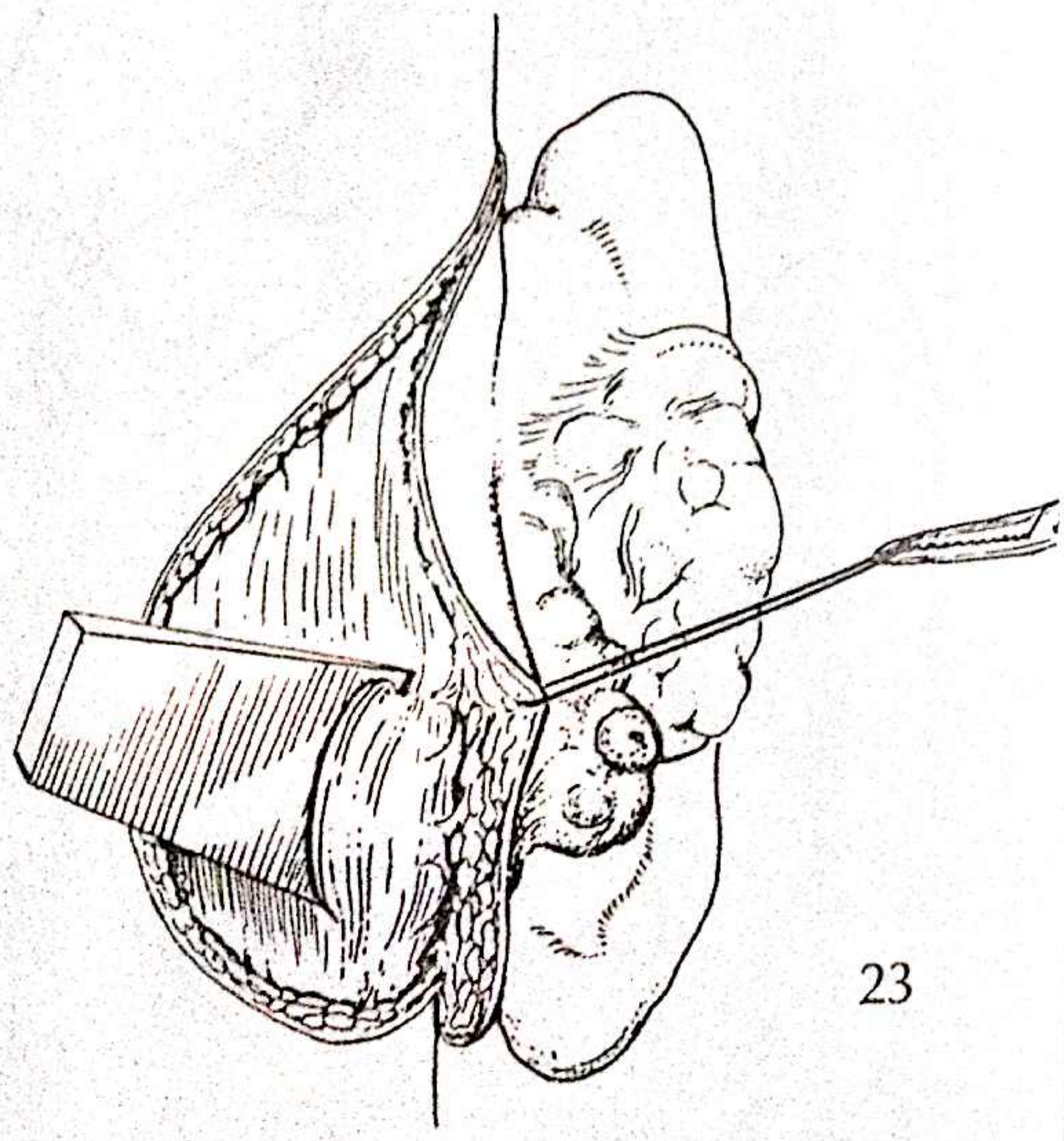
21



22

22 & 23

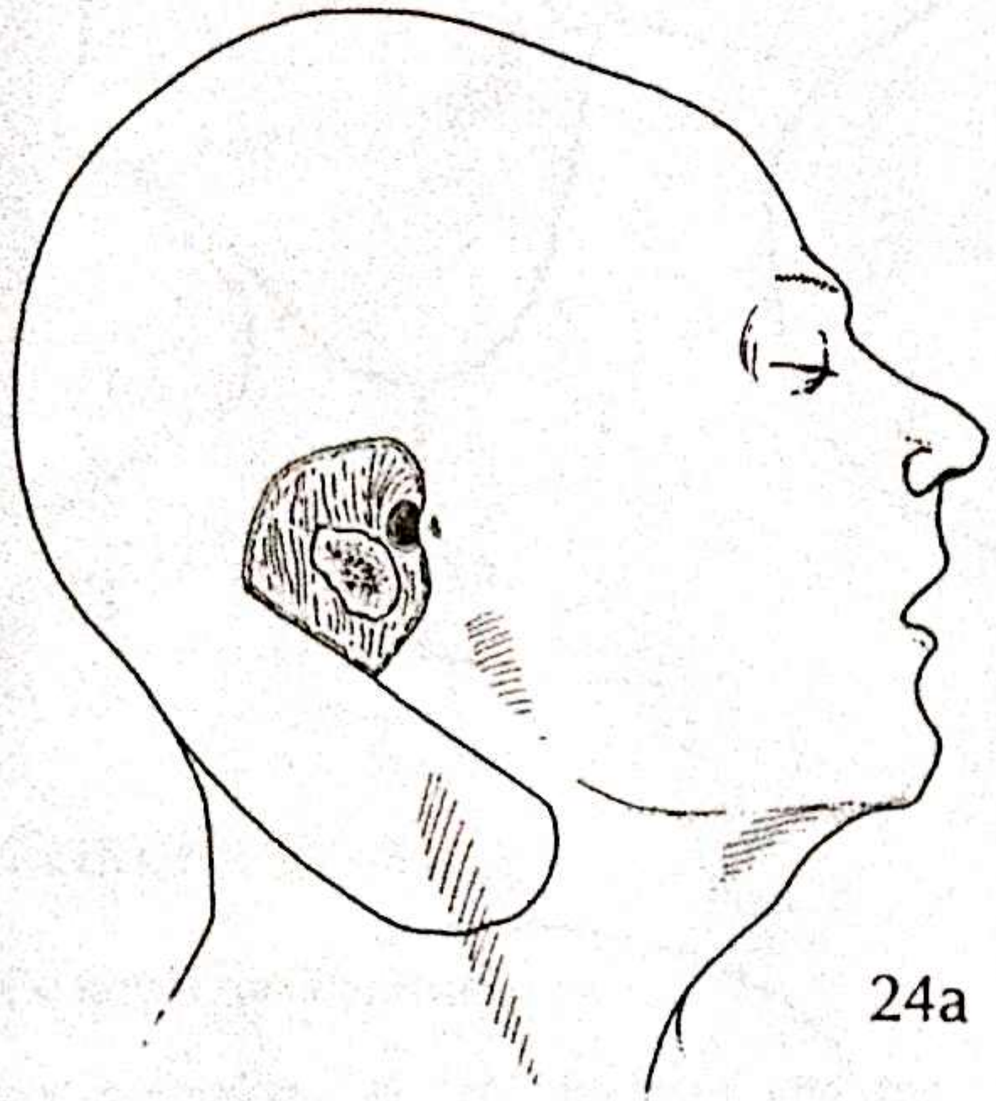
More extensive tumours may require excision of the mastoid periosteum, often with the mastoid prominence itself.



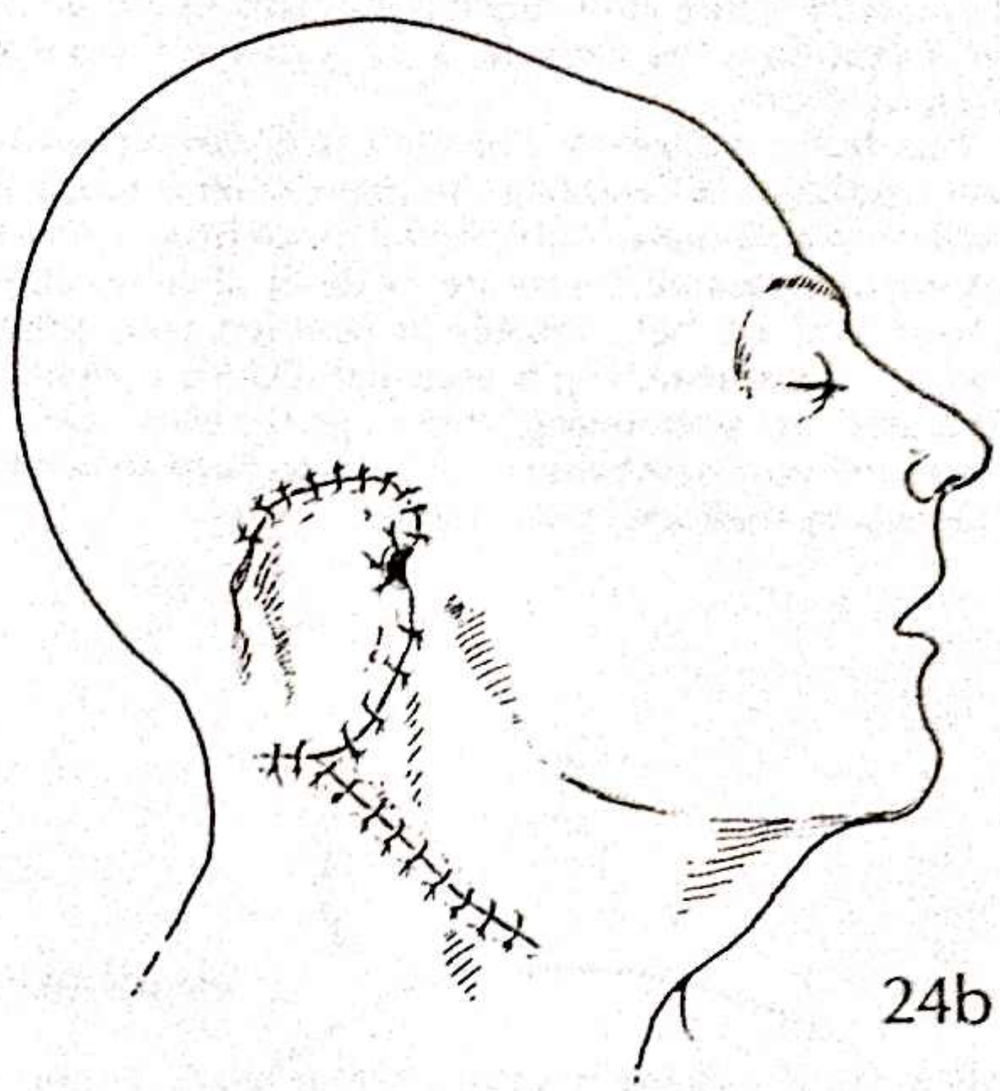
23

24a–d

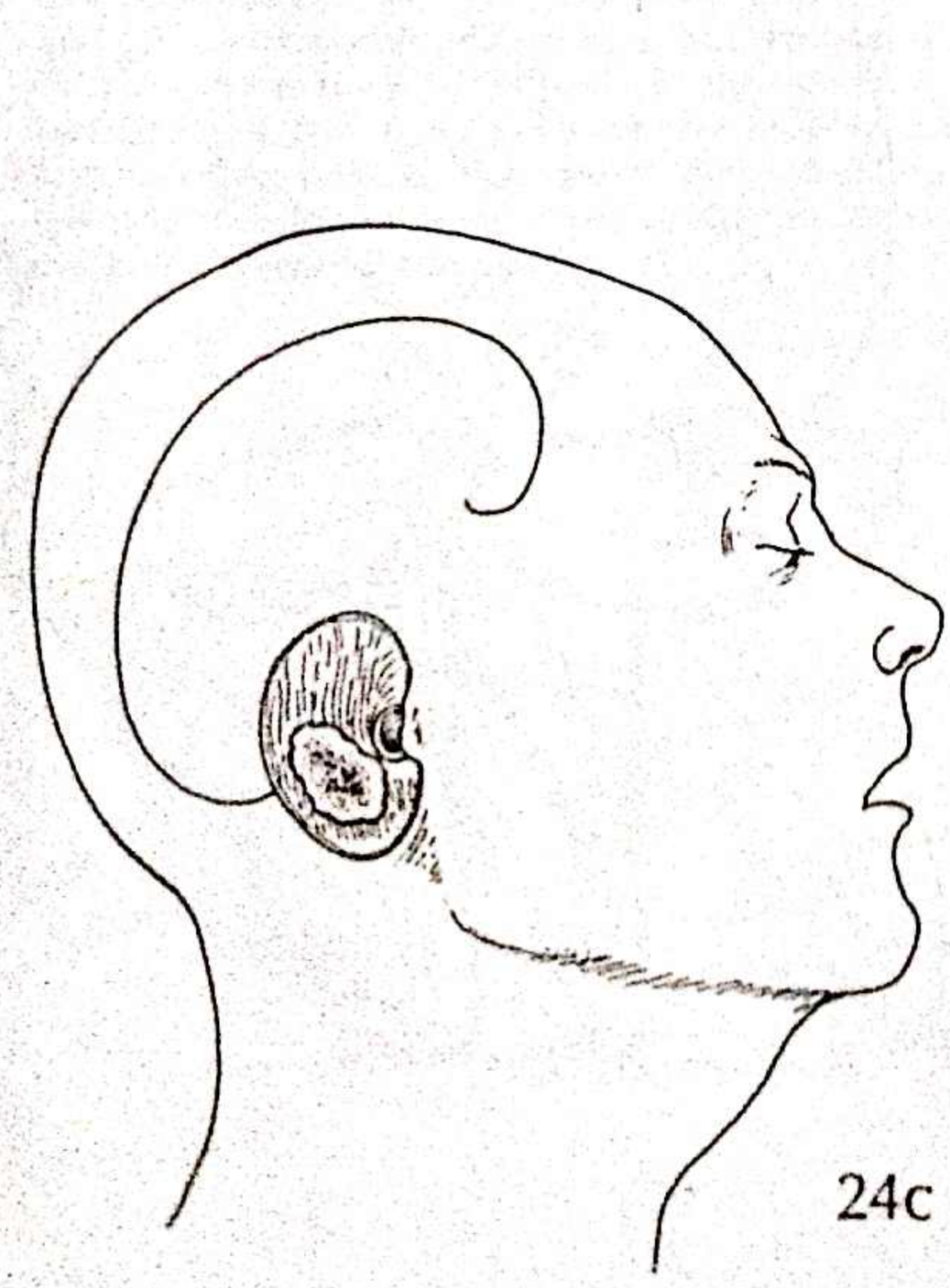
These patients require skin flap repair by transposition of a skin flap from the neck (*a* and *b*) or by a rotation scalp flap from the temporoparietal region (*c* and *d*).



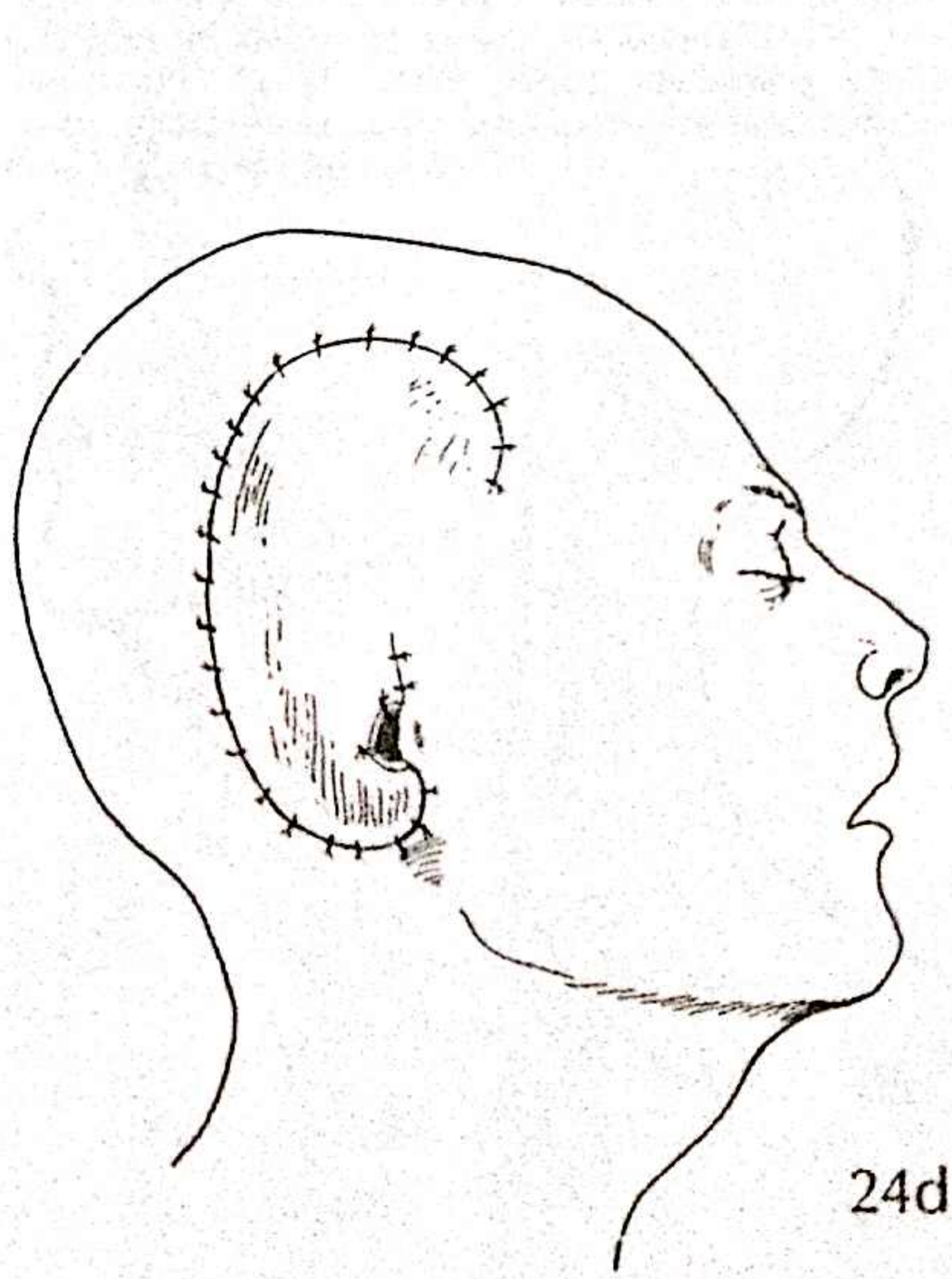
24a



24b



24c

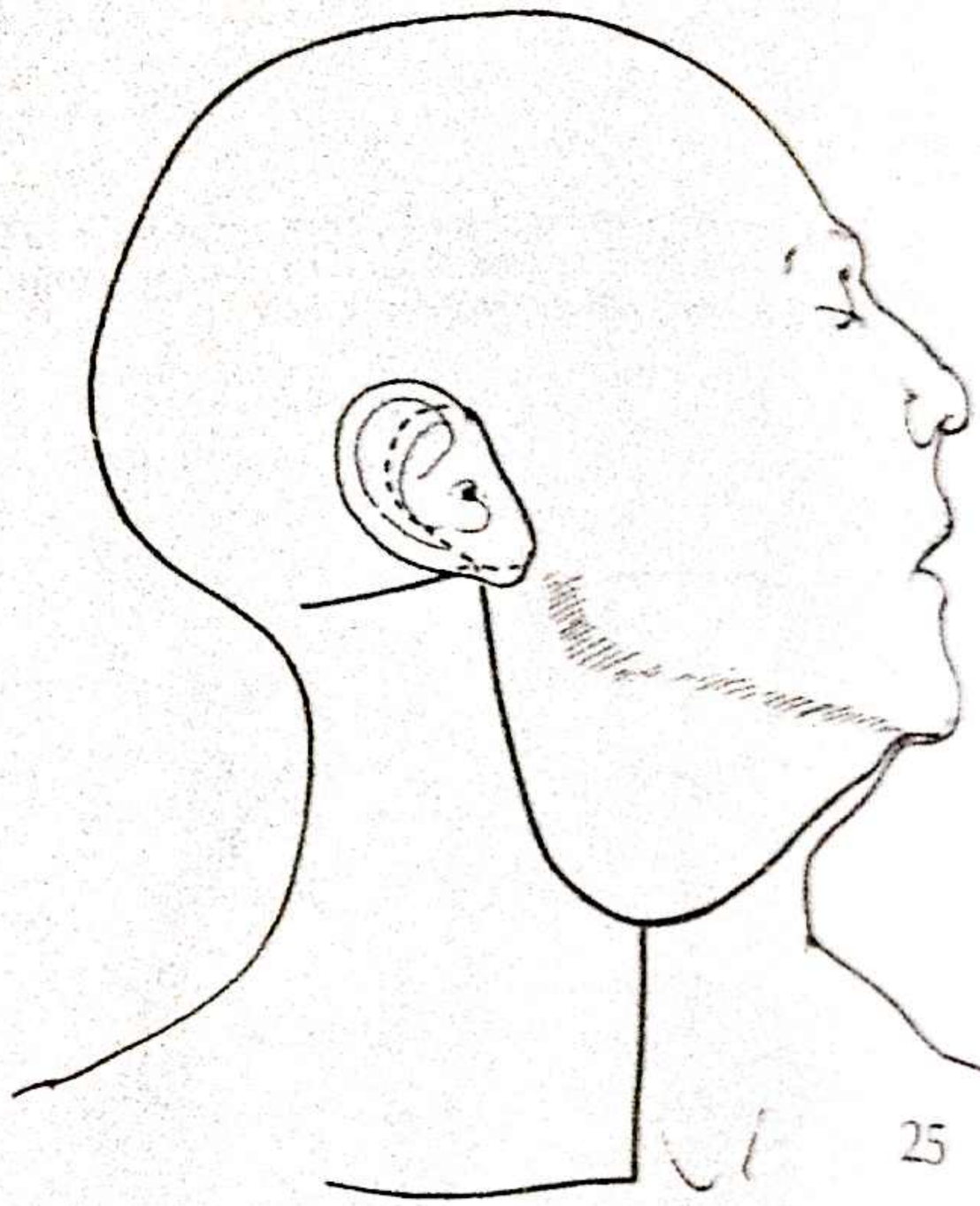


24d

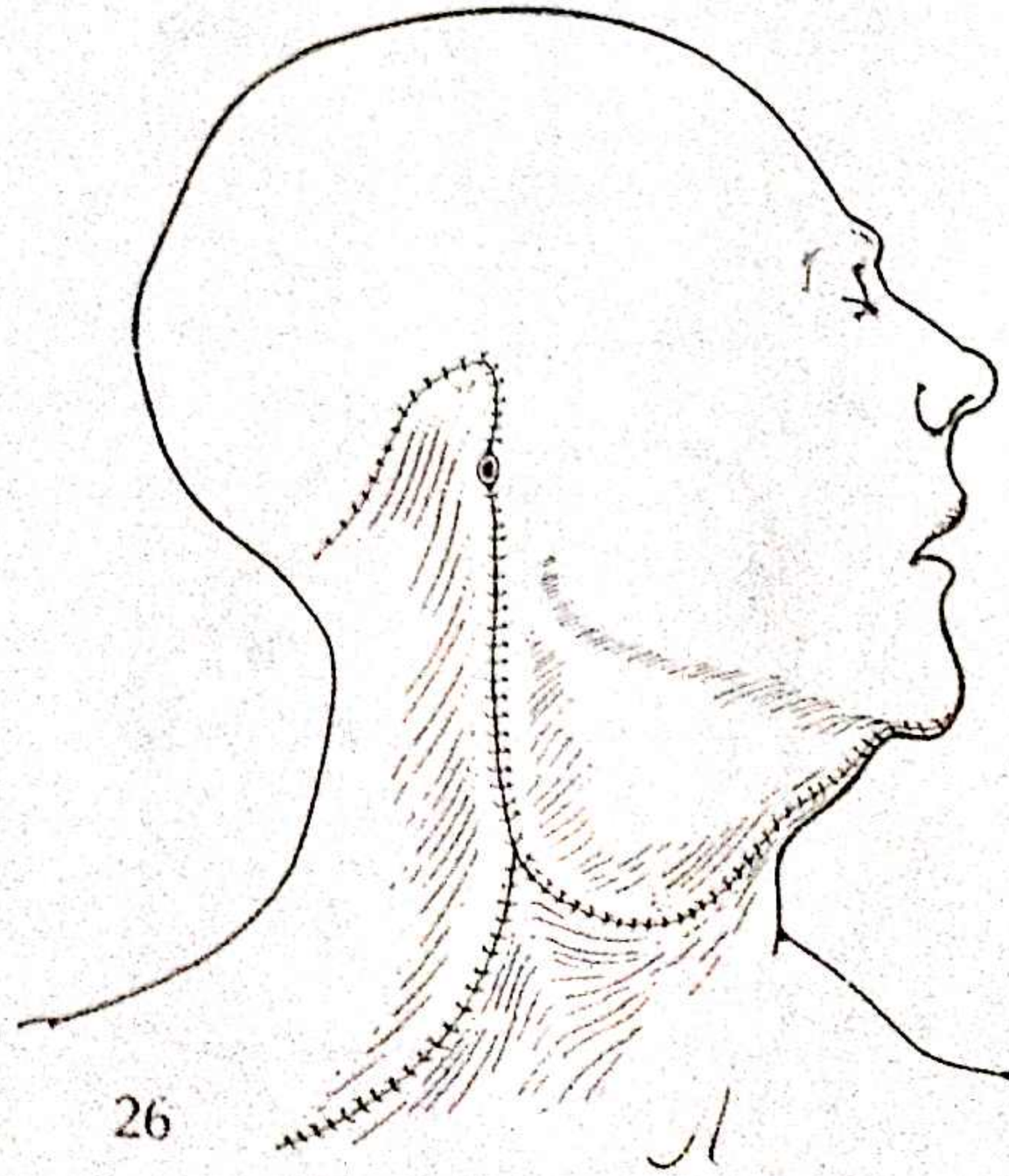
25, 26 & 27

Squamous cell carcinoma of the ear may present with metastatic tumour in the cervical nodes already palpable. Removal of the pinna in continuity with block dissection of the neck is required, and skin closure may be achieved by primary suture after rotation upwards of the posterior neck skin flap. Alternatively, a scalp rotation flap may be used as above.

Prosthetic replacement of the ear is carried out when scar resolution is complete. An impression is taken of the cavity and a plaster-of-Paris model made from it. The most satisfactory prosthetic ears are made of silicone rubber or Silastic and are held reliably in position with adhesive. Careful colour matching is essential. Elderly patients have difficulty in positioning these prostheses and it is therefore more satisfactory for them to have an acrylic ear attached to their spectacle frames.



25



26

Illustrations by Patrick Elliott

Removal of foreign bodies from the external auditory meatus

N. W. Gill FRCS
Formerly Consultant Ear, Nose and Throat Surgeon, South Manchester Hospitals, Manchester, UK

Preoperative

General considerations

Foreign bodies can be introduced into the external auditory meatus with relative ease, but removal is difficult because they tend to impact at the junction of the cartilaginous and bony parts of the meatus. Unskilled attempts at removal may push the offending object inwards and cause traumatic perforation of the drum and perhaps damage to the middle ear.

Anaesthesia

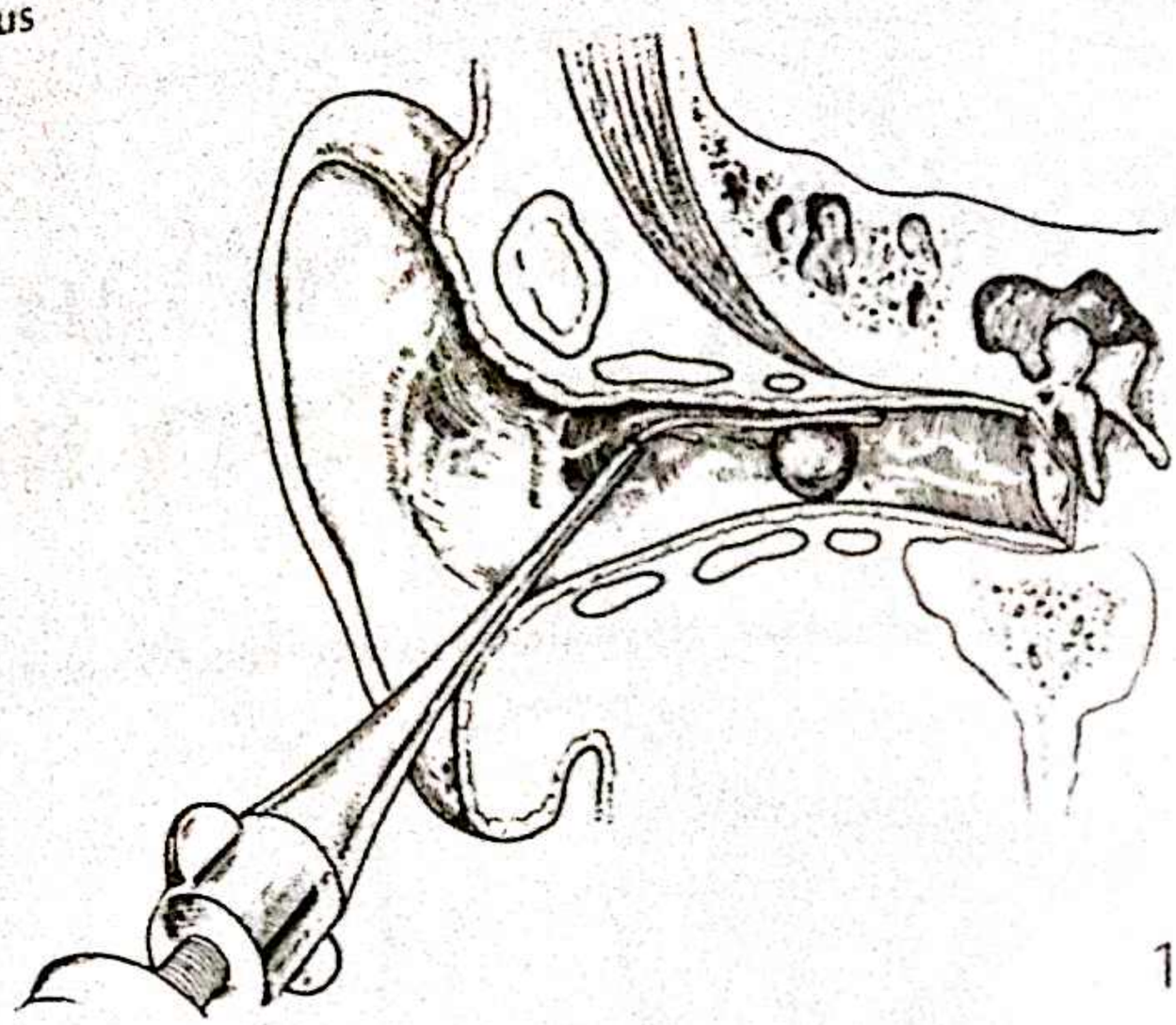
In adults, if the foreign body is small, clearly visible and not hidden in debris or blood, an anaesthetic is usually unnecessary. In all other cases, including children, general anaesthesia with adequate premedication and intubation should be used.

Techniques

1

Syringing

Small, unimpacted foreign bodies can be removed by syringing. If animate, the object should first be killed by instillation of a few drops of chloroform. Syringing should then be carried out with isotonic (normal) saline at blood heat in an aural syringe, taking care that the stream of saline is directed towards the posterosuperior meatal wall.

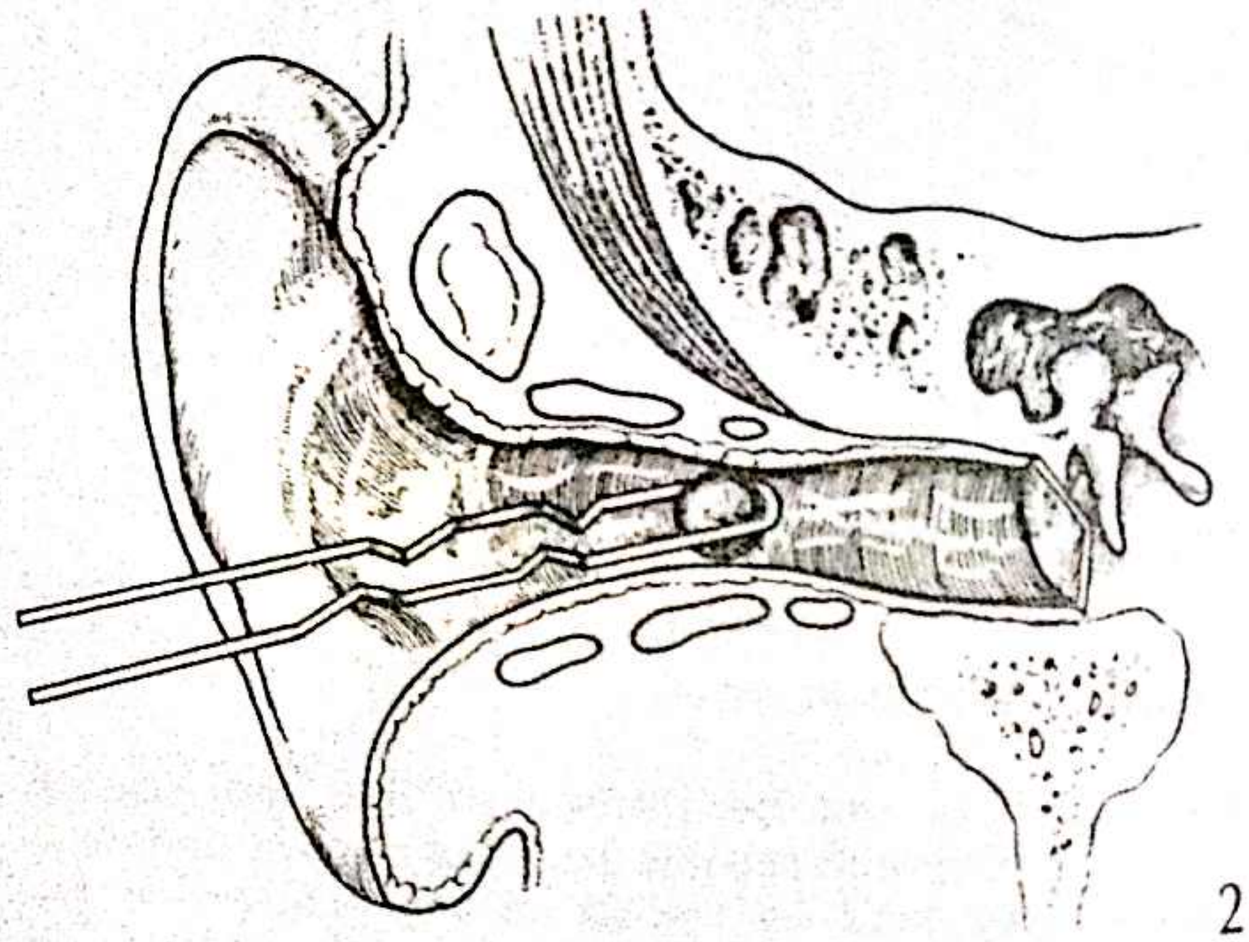


1

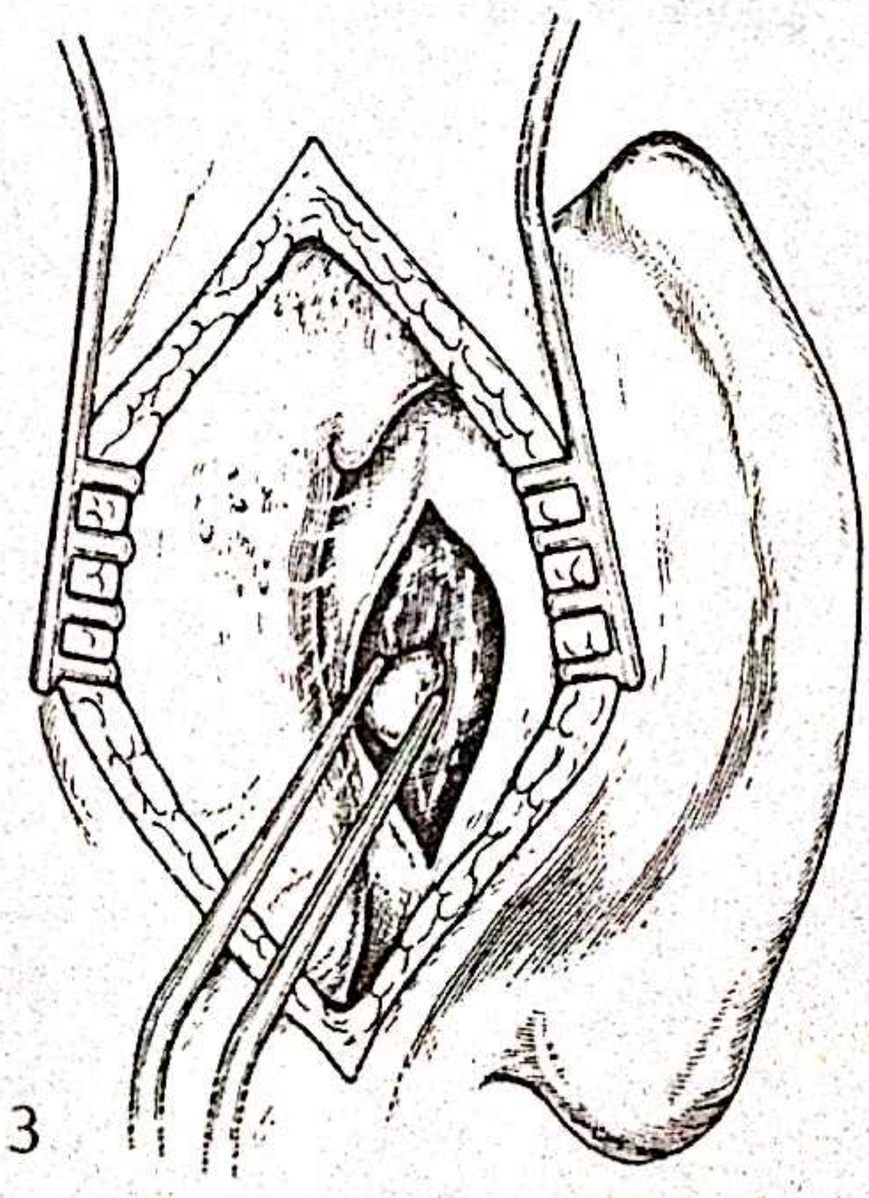
2

Instrumental removal

An impacted solid foreign body can be removed with a fine blunt hook, a fine cerumen scoop or the blunt end of a fine hair pin. Under good illumination and general anaesthesia one of these instruments is inserted behind the object and manoeuvred until it catches on its distal surface.



2



3

3

Open operation

This is seldom necessary. A formal postaural incision as for cortical mastoidectomy is made down to bone and the tissues are put firmly on the stretch with retractors. A transverse incision is made through the posterior meatal wall just in front of the foreign body, which is then levered out and delivered through the incision. If the object is firmly impacted the posterior part of the bony meatus is removed with a burr and dental drill to facilitate delivery of the foreign body through the incision. After all bleeding has been staunched, the postaural wound is closed and the external meatus is packed with BIPP gauze. This should be removed at the end of one week, after which generally no further treatment is necessary.

Illustrations by Patrick Elliott

Surgical treatment of meatal exostoses

N. W. Gill FRCS
Formerly Consultant Ear, Nose and Throat Surgeon, South Manchester Hospitals, Manchester, UK

Preoperative

General considerations

Large solitary osteomata and meatal exostoses are different conditions. The former are usually unilateral, pedunculated, large and of cancellous bone, and lie in the outer part of the bony external auditory meatus. They cause retention of wax and debris, and ultimately external otitis and, because of their size, deafness. They should be removed.

The latter are usually bilateral, sessile and of compact bone, and lie in the inner part of the meatus, hard on the bony annulus tympanicus. They are hardly ever associated with retention of debris and rarely large enough to cause deafness. However, when chronic suppurative otitis media coexists they may make efficient conservative treatment impossible and thus need to be removed. Otherwise, they should be left alone.

Anaesthesia and position of the patient

General anaesthesia with adequate premedication and intubation is required. Position of the patient and instrumentation are as for mastoid operation.

The operation

LARGE SOLITARY OSTEOMA

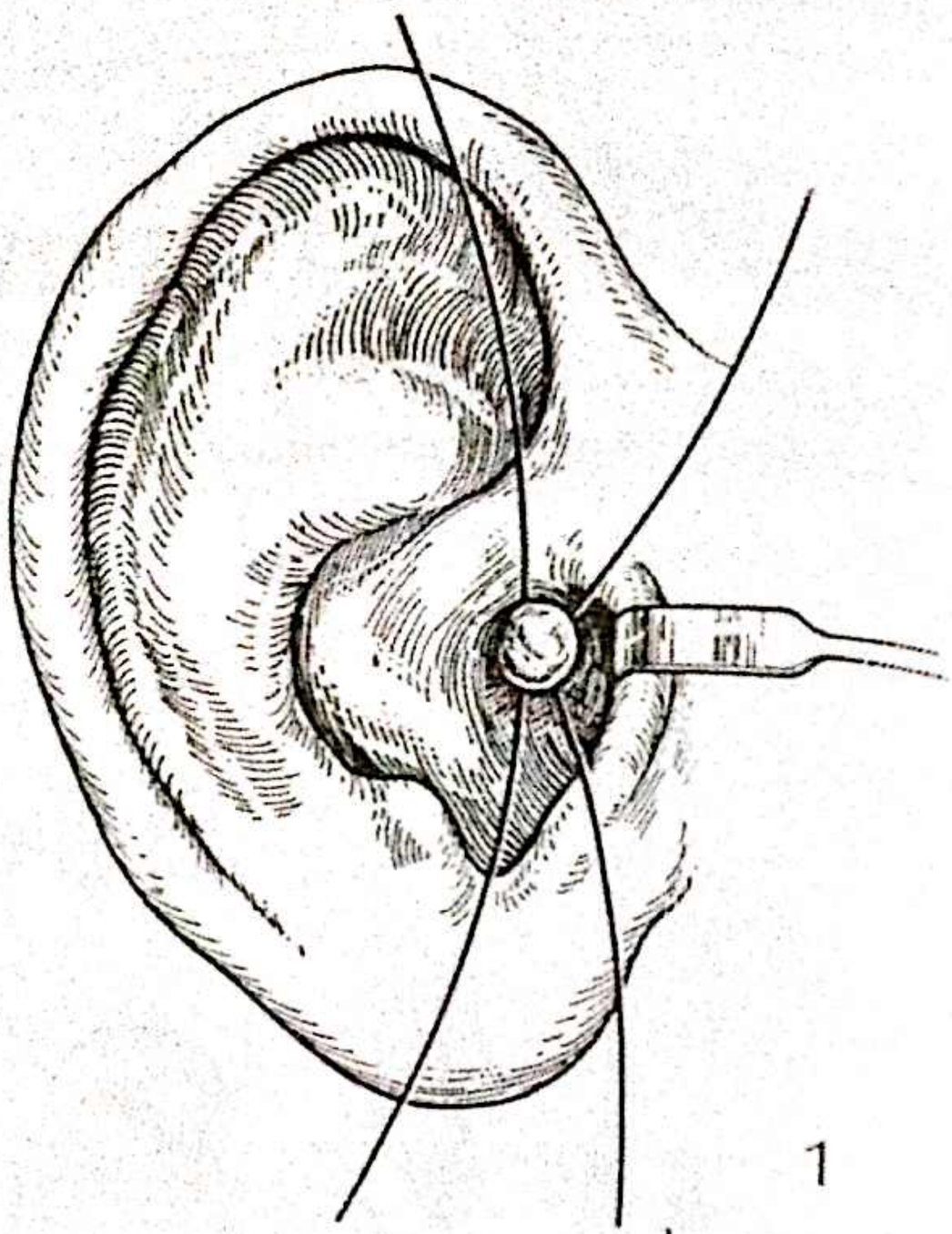
The approach

No incision is necessary. The size of the pedicle is assessed with a fine probe or wire.

Fine pedicle

1

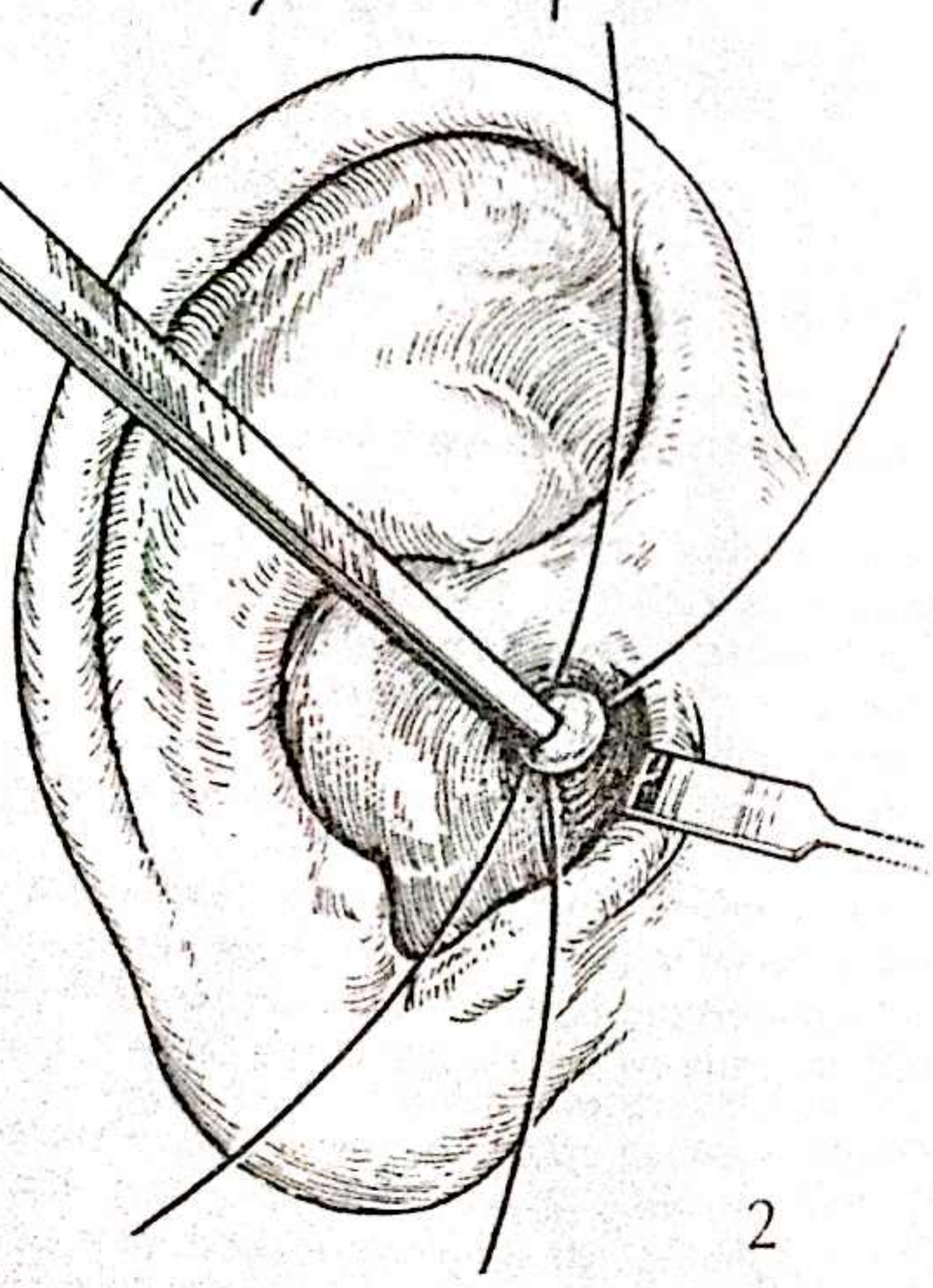
Two fine lengths of fuse wire are passed under the osteoma to form a sling.



1

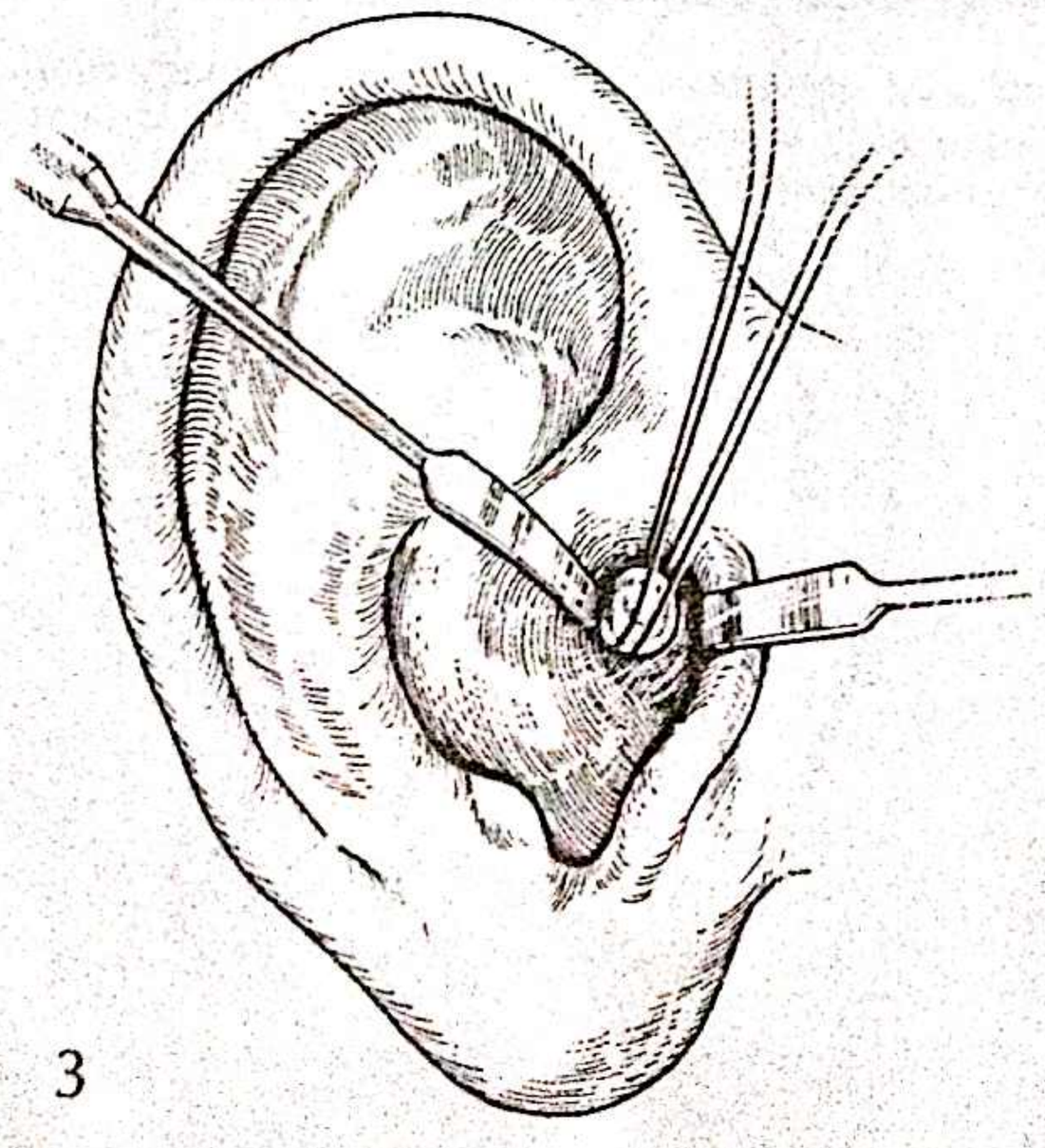
2

The pedicle is snapped by placing a blunt instrument on the convex outer surface of the growth and giving it a smart tap with a hammer.



2

3



3

The osteoma is levered out with the curved end of a small McDonald elevator and traction on the wire sling. A small pledget of Gelfoam is placed over the bare area of bone left behind.

Broad pedicle

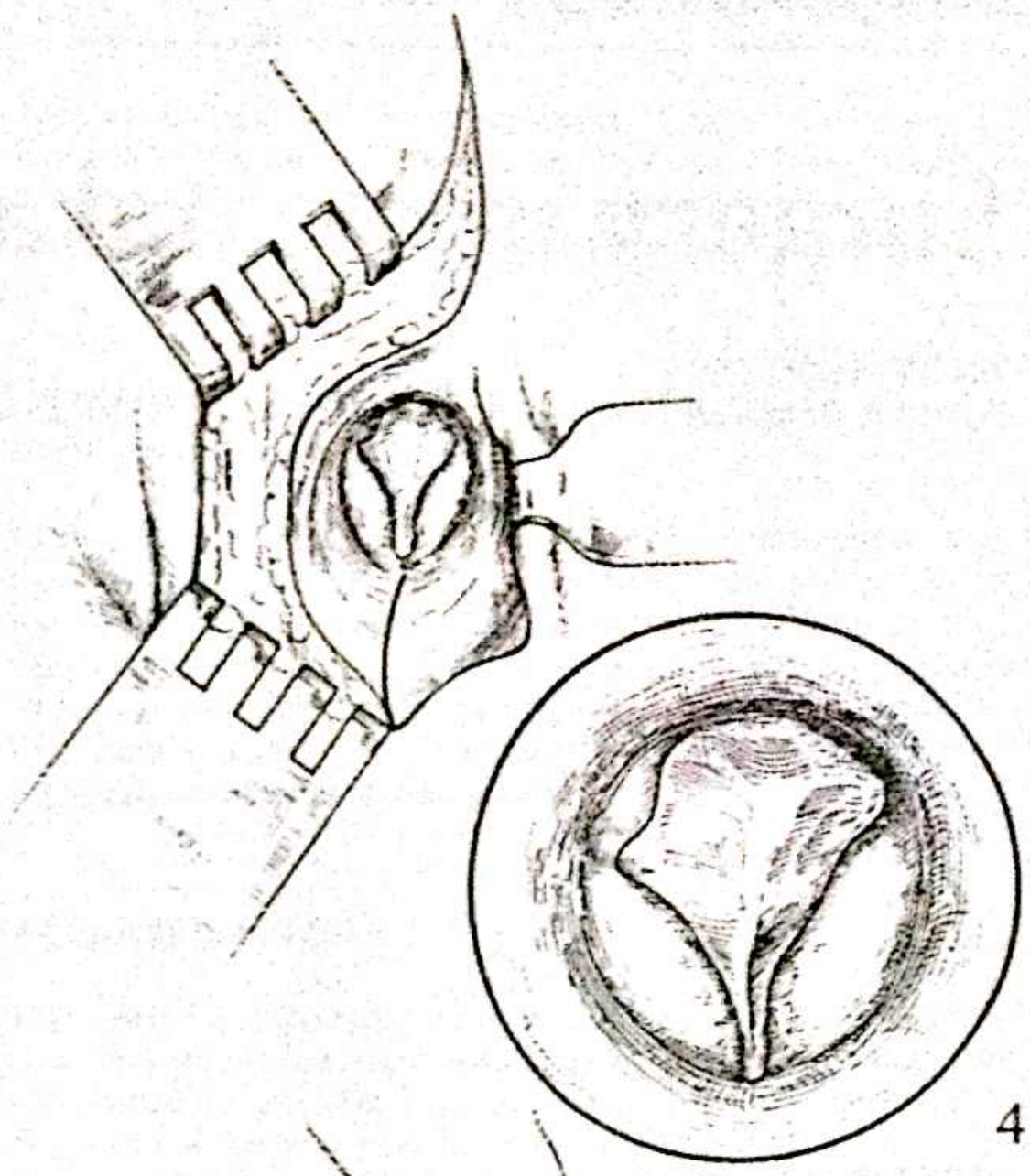
Using a dental drill and a straight cutting burr the osteoma is removed piecemeal. This is extremely easy, even if the bone is dense. The residual bare area is covered with Gelfoam.

MEATAL EXOSTOSES

4

The approach

A formal endaural incision is made as for radical mastoidectomy and the pinna and underlying tissues are retracted. The skin is incised along the floor of the meatus, starting at 6 o'clock on the free edge of the incision. The flap is elevated to expose the exostosis lying under it.



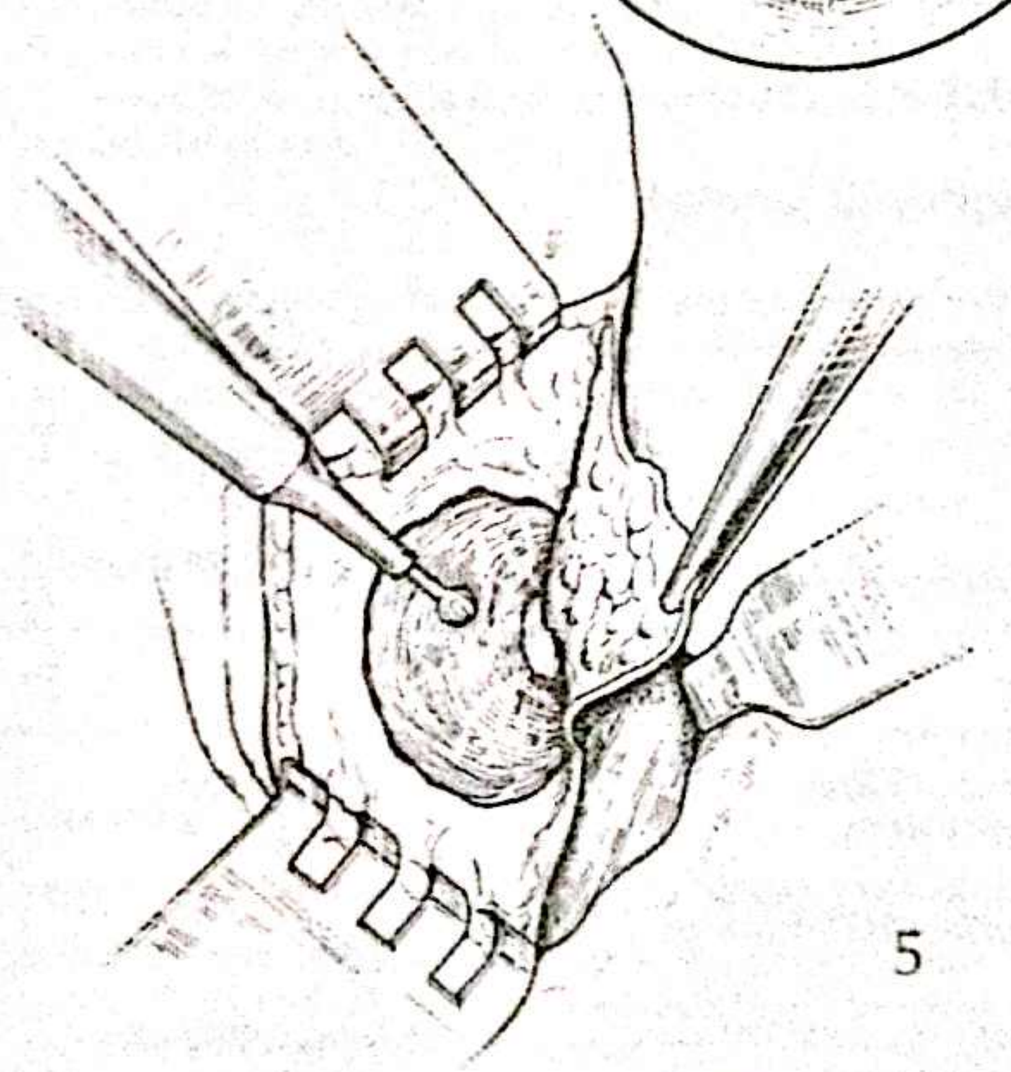
4

5 & 6

The exostosis is removed using a dental drill and a straight cutting burr. Do not use a chisel or gouge and mallet, or the facial nerve will inevitably be damaged. Particular care must be exercised when working near the annulus tympanicus posteriorly, posteroinferiorly and posterosuperiorly, as the facial nerve is in close proximity. The flap is then replaced, a Gelfoam pack inserted and the incision sutured.

Meatal exostoses in the anterosuperior and anteroinferior quadrants of the external meatus seldom grow to any great size, and consequently removal of the posterior exostoses is all that is necessary for access to the drum.

If, at this stage, it is realized that the state of the middle ear calls for surgical intervention it is relatively easy to proceed with the appropriate operation on the mastoid process and middle ear.



5

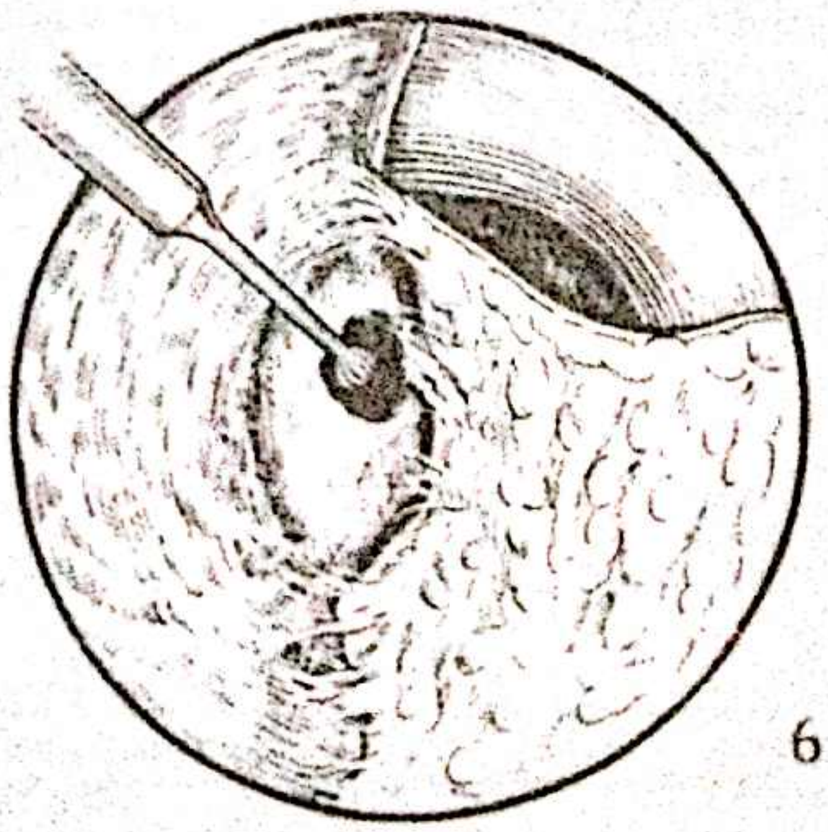
Postoperative care

Large solitary osteoma

No further treatment is usually necessary except occasionally clearing of debris in the external meatus by suction 1 week after operation. The Gelfoam disintegrates and is discharged with the wax from the ear.

Meatal exostosis

The Gelfoam pack and stitches are removed after 1 week and the external meatus is cleaned at regular intervals until it is dry. If radical surgery has been undertaken on the middle ear and mastoid the after-treatment for this is necessary.



6

Illustrations by R. A. H. Neave

Surgery of meatal atresia

N. W. Gill FRCS
Formerly Consultant Ear, Nose and Throat Surgeon, South Manchester Hospitals, Manchester, UK

Preoperative

CONGENITAL ATRESIA

Maldevelopment of the external auditory meatus is always associated with maldevelopment of the middle ear. The inner ear is very seldom affected. It may be unilateral or bilateral, is more common in males, and cases fall into four main categories (*see* Table).

Classification of congenital meatal atresia

Type I	*Type II*	*Type III*	*Type IV*
A normal or slightly deformed pinna	Pinna deformed either minimally or grossly	Gross deformity of pinna	Almost normal pinna
External auditory meatus present in at least the inner third	No external auditory meatus	No external auditory meatus	Almost normal external auditory meatus but normal curves exaggerated
Tympanic membrane always present but may be deformed or ossified	No tympanic membrane	No tympanic membrane	Tympanic membrane normal
Malleus, incus and stapes all present and distinct but may be slightly deformed	Only head of malleus present and may be fused with incus. Long process of incus may be present, represented by a strand of tissue going to capitellum of stapes, or absent. Stapes usually present and normal or slightly deformed	Ossicles not present, or unrecognizable	Normal malleus. Incus grossly deformed. Stapes grossly deformed or absent
Middle ear cleft, mastoid process, Eustachian tubes and cushion normal	Middle ear cleft, mastoid process, Eustachian tubes and cushion almost normal	No middle ear cleft or only a few cells present. Mastoid process densely sclerotic or Eustachian cushion deformed	Middle ear cleft, mastoid process and Eustachian tubes and cushion normal

Types III and IV are usually found in association with the Treacher–Collins syndrome.
There may be overlap between the different types. For example, it is not uncommon for type I cases to show stapedial malformations.

Investigations

A radiograph of the mastoid process, including tomography if necessary, will demonstrate (*1*) the cellular development of the mastoid; (*2*) the presence of part of the external auditory meatus or its absence; (*3*) the presence of ossicles; and (*4*) the presence of cochlea and labyrinth. A full clinical and audiometric analysis of the hearing must be made. Any upper respiratory tract infection should be dealt with, and the opportunity must be taken while the adenoids are being removed to assess the state of the Eustachian cushions.

Indications

All bilateral cases should be seriously considered for surgery. If suitable, one ear should be operated on between the ages of 12 and 18 months.

In unilateral cases there is no urgency and indeed no necessity for surgery at all according to some authorities. For speed of recovery and healing the best time for surgery in unilateral cases is after puberty, but for educational reasons it is usually preferable to carry out the operation between the ages of 5 and 8 years.

Good results can be expected in types I and II, but surgery should not be attempted in type III cases as benefit to the patient cannot be expected. Type IV cases are best left until adult life when patients can make their own decision. They can easily be fitted with hearing aids.

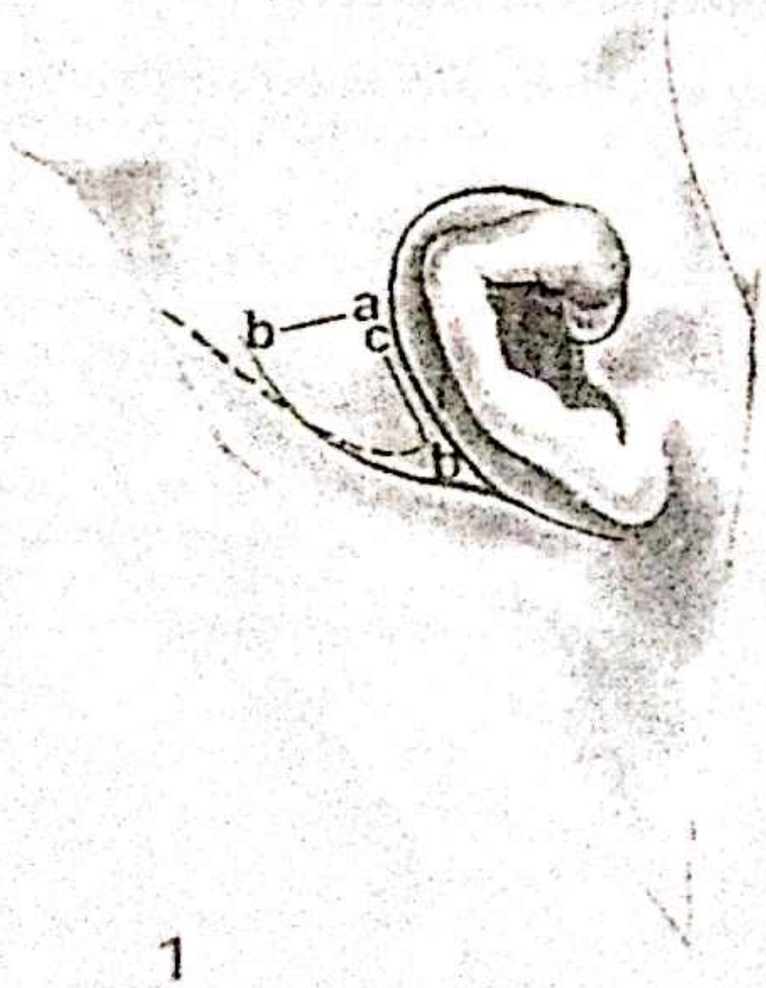
Anaesthesia, position of patient and instrumentation

General anaesthesia with adequate premedication and intubation is necessary. The position of the patient is as for the radical mastoid operation. No attempt at this operation should be made without a full set of mastoid implements, including a dental drill and straight burrs, fine hooks and scoops, as used in stapedectomy, and adequate illumination and magnification.

ACQUIRED ATRESIA

This may be traumatic or inflammatory. If there is no deafness the traumatic cases may be left alone, but the inflammatory atresias may hamper treatment to such a degree that surgery may become inevitable.

Preoperative investigation and anaesthesia are as for congenital atresia.



1

The operation

CONGENITAL ATRESIA

1

The incision

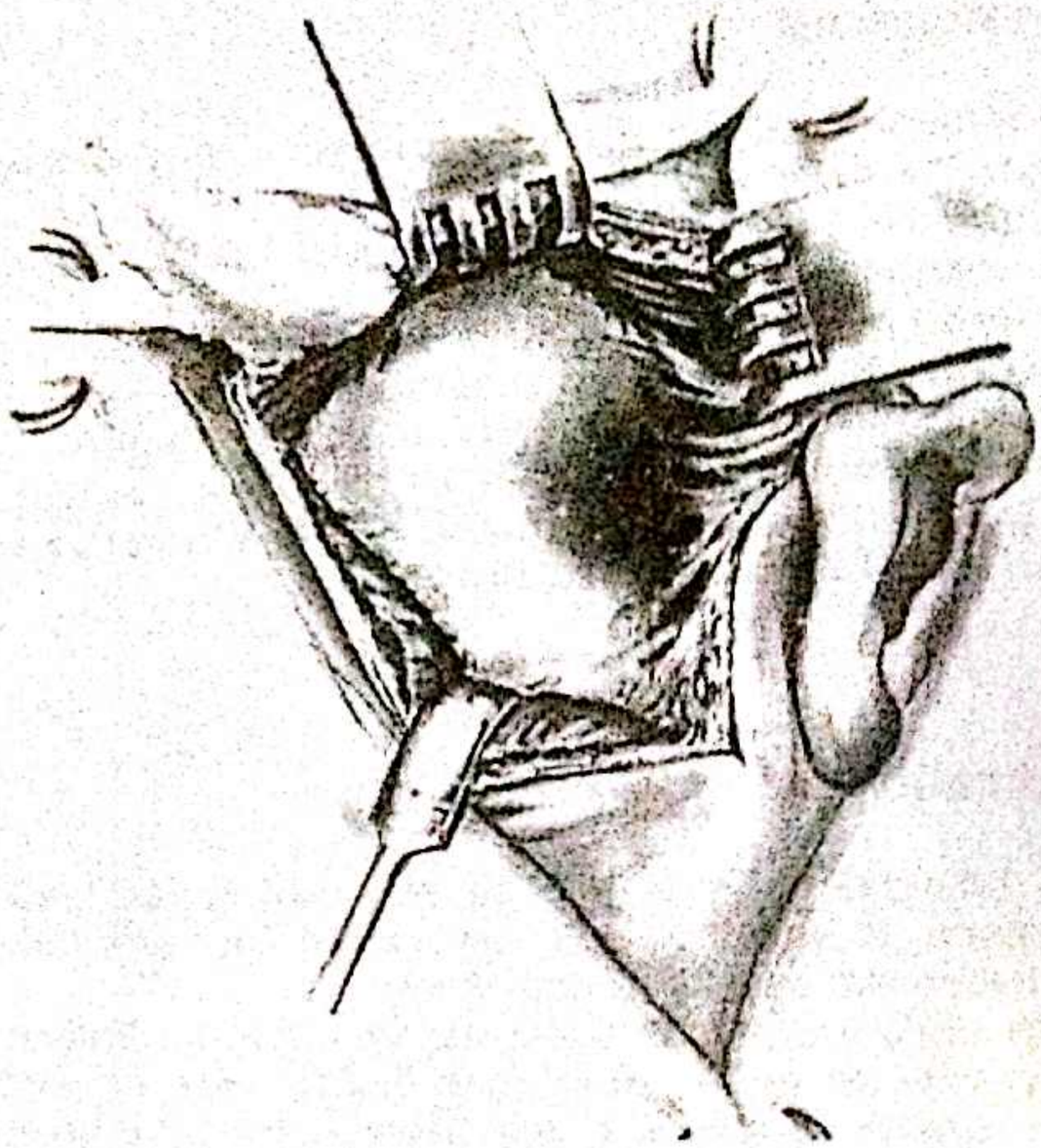
The pinna is always situated away from its normal position, forwards and downwards towards the angle of the jaw.

A Z-plasty is therefore done so that the final position of the new external auditory meatus is at its normal position. This is necessary however normal the pinna appears to be. The more normal the pinna the shorter the distances *a–b* and *b–c* must be. In very abnormal pinnae these distances should be increased.

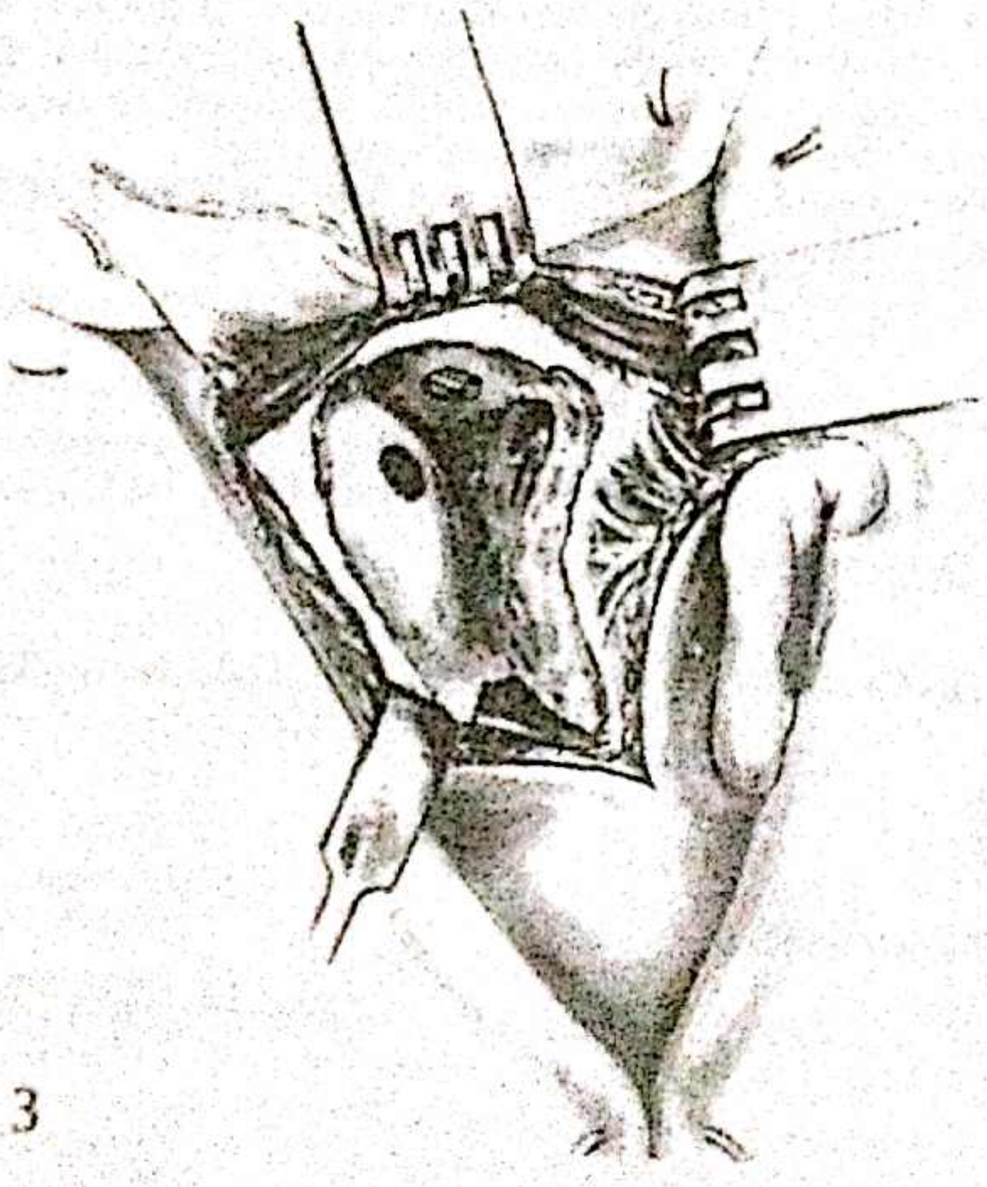
2

This incision is carried down through skin and superficial fascia to deep fascia and the flaps are dissected up, backwards and forwards.

The insertion of the sternomastoid muscle and both muscles are elevated from the bone and retracted.



2



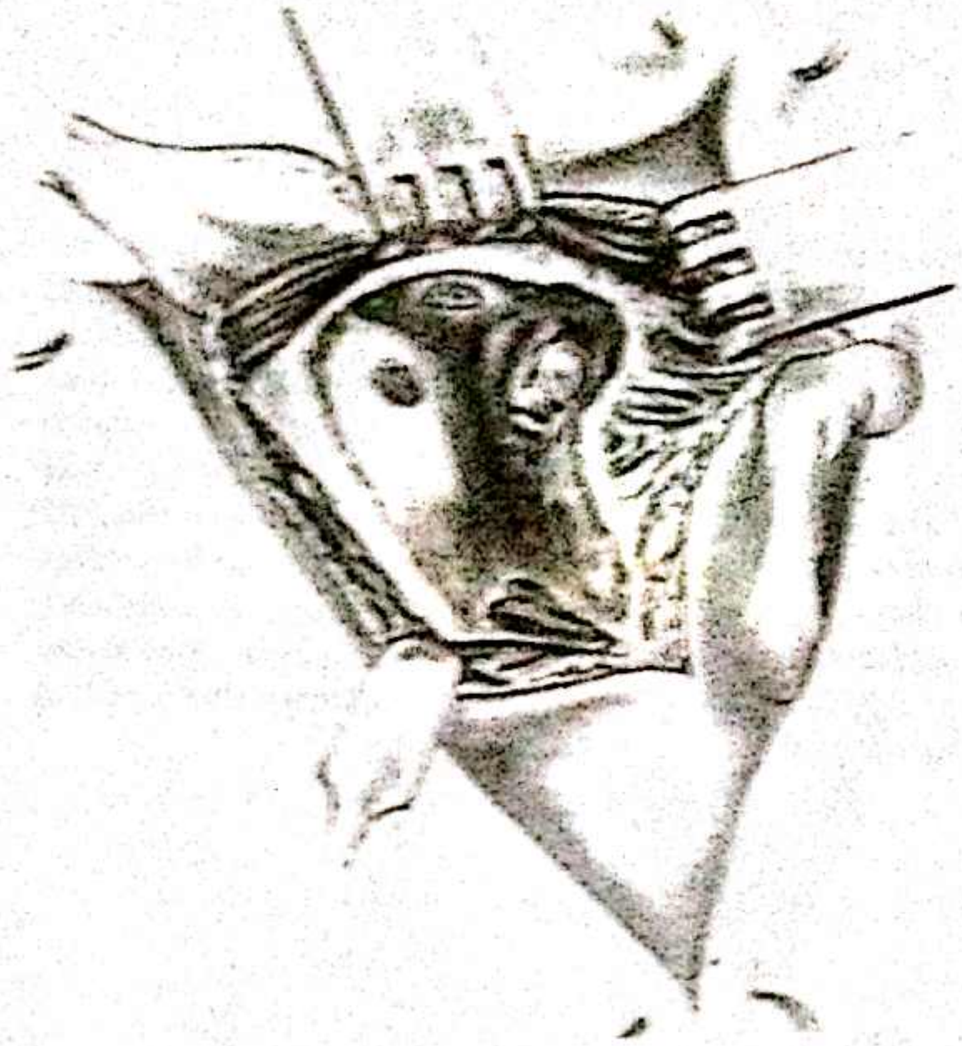
3

3

Exenteration of mastoid process

Since in my experience over 50 per cent of these cases have an infection of the mastoid, it is necessary to exenterate the process.

The only constant landmarks are the dura, the lateral sinus and the mastoid tip. Any other apparent surface landmarks should be ignored. By working between these three landmarks the antrum can be entered and the exenteration completed. The mastoid tip should be excised down to the posterior belly of the digastric muscle, and particular attention should be paid to the cells between this muscle and the jugular bulb, as at the end of the operation the cut insertion of sternomastoid muscle is put into this area to obliterate it.

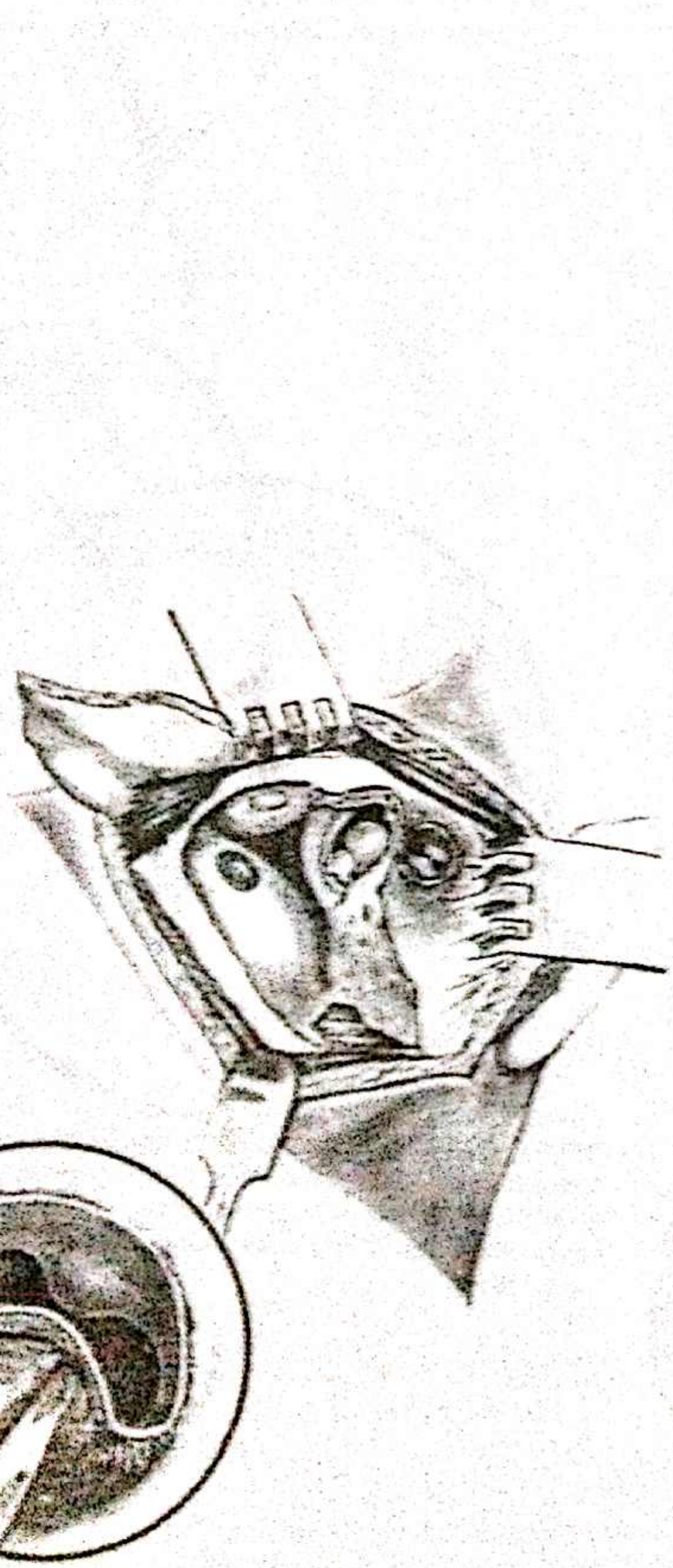


4

4

Exposure of ossicles

The aditus is followed upwards until the incus and then the malleus is identified. Progress beyond this point depends on the type of deformity.



5

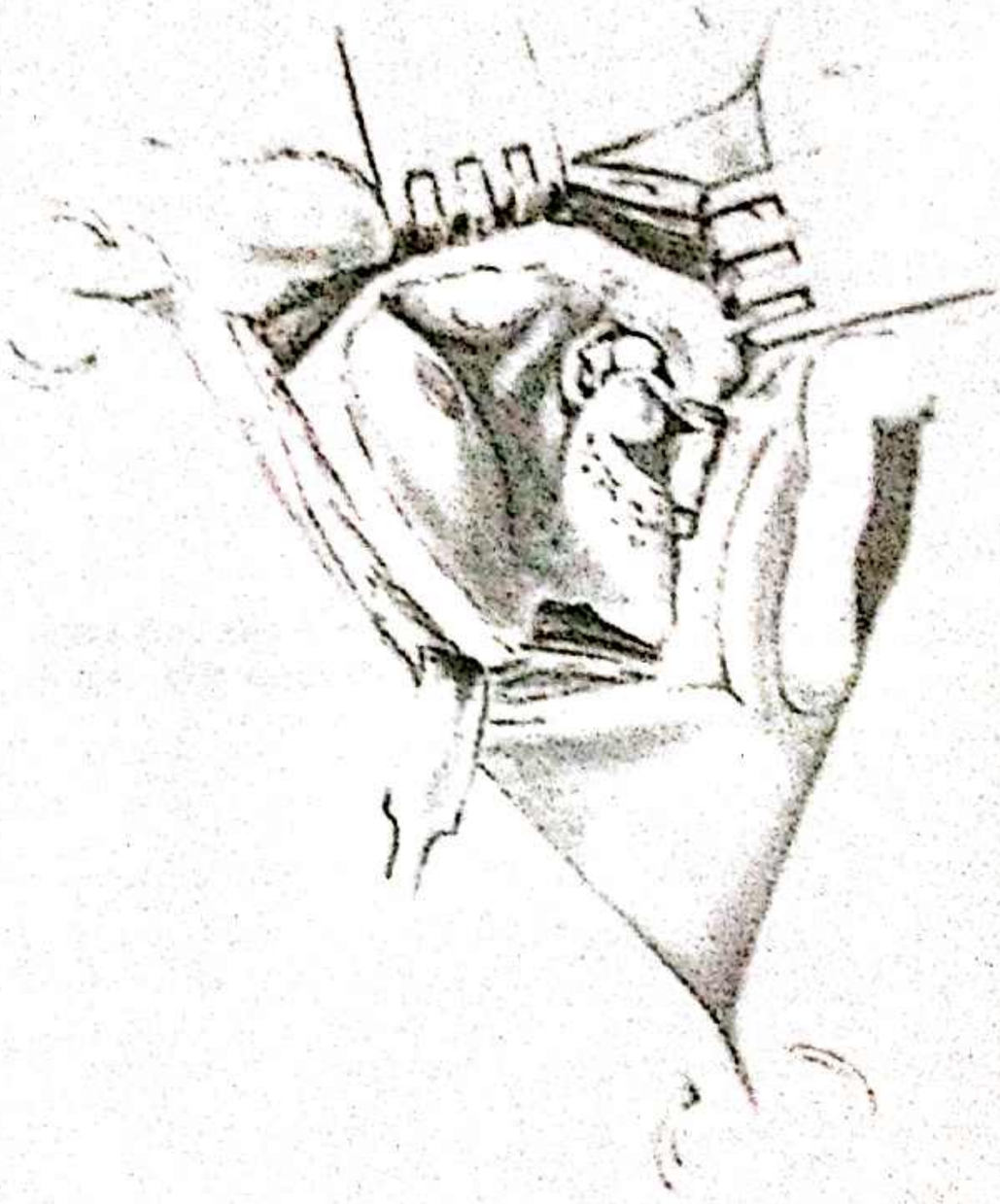
Type I cases

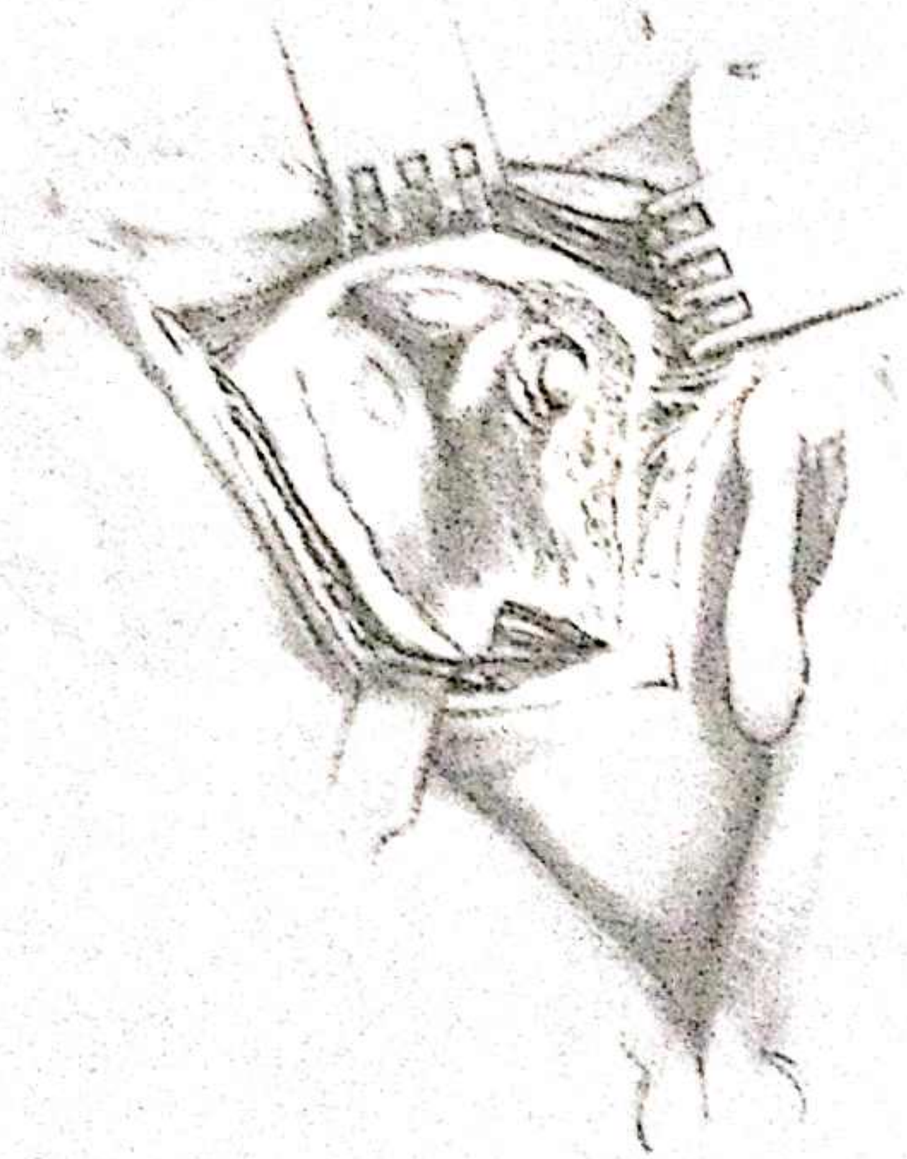
5

If the meatus is present in its entirety, the meatal skin is elevated and the underlying bony meatus enlarged with a dental burr, working at first on the posterior and inferior aspects. The stenosis is always greatest at the proximal end of the meatus and is caused by enlargement of the inferior and anterior endomeatal spines. Once the inferior meatal spine has been burred away, the posterior and anterior parts of the meatus can be enlarged. The meatal skin is then elevated superiorly and anteriorly and the anterior endomeatal spine is smoothed off with a burr. The resulting sleeve of meatal skin will be too thin to fill the new meatus and should therefore be incised along the floor and laid back along the meatal wall as for acquired atresia and packed into position with a BIPP pack.

6

When the external meatus is present only in its inner two-thirds, the bony external meatus is identified and entered through its posterior wall. The outer attic wall is removed leaving only the annulus tympanicus. A communication is then made between the rudimentary meatus and the mastoid bowl by burring away the posterior wall and bony obstruction, which is usually a grossly enlarged and deformed anterior meatal spur. The drum and ossicles are then tested for mobility. If this is satisfactory, a Heath's type mastoidectomy is performed. If they are immobile, the bridge, drum and ossicles should be removed and the operation continued as in type II cases.



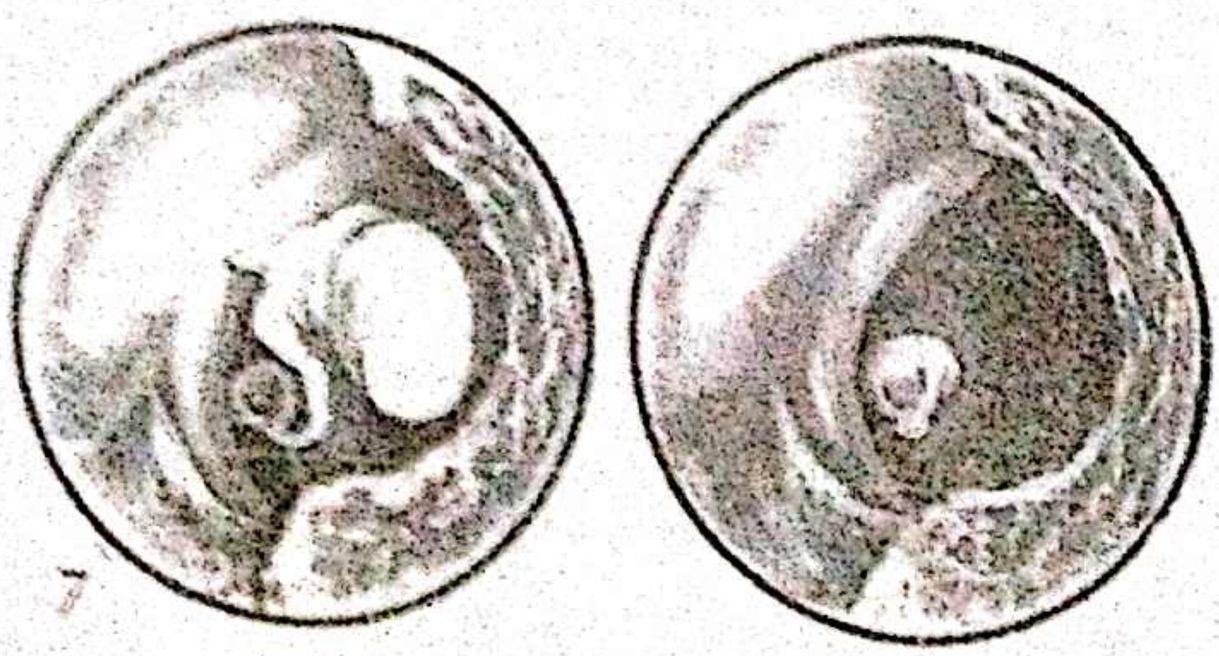


6

Type II cases

7

There is no external auditory meatus in these cases, the head of the malleus arising directly from a boss of bone on the posterior surface of the anterior wall of the mastoid process. There is no handle to the malleus and any of the malformations of the ossicular chain described earlier may be present.

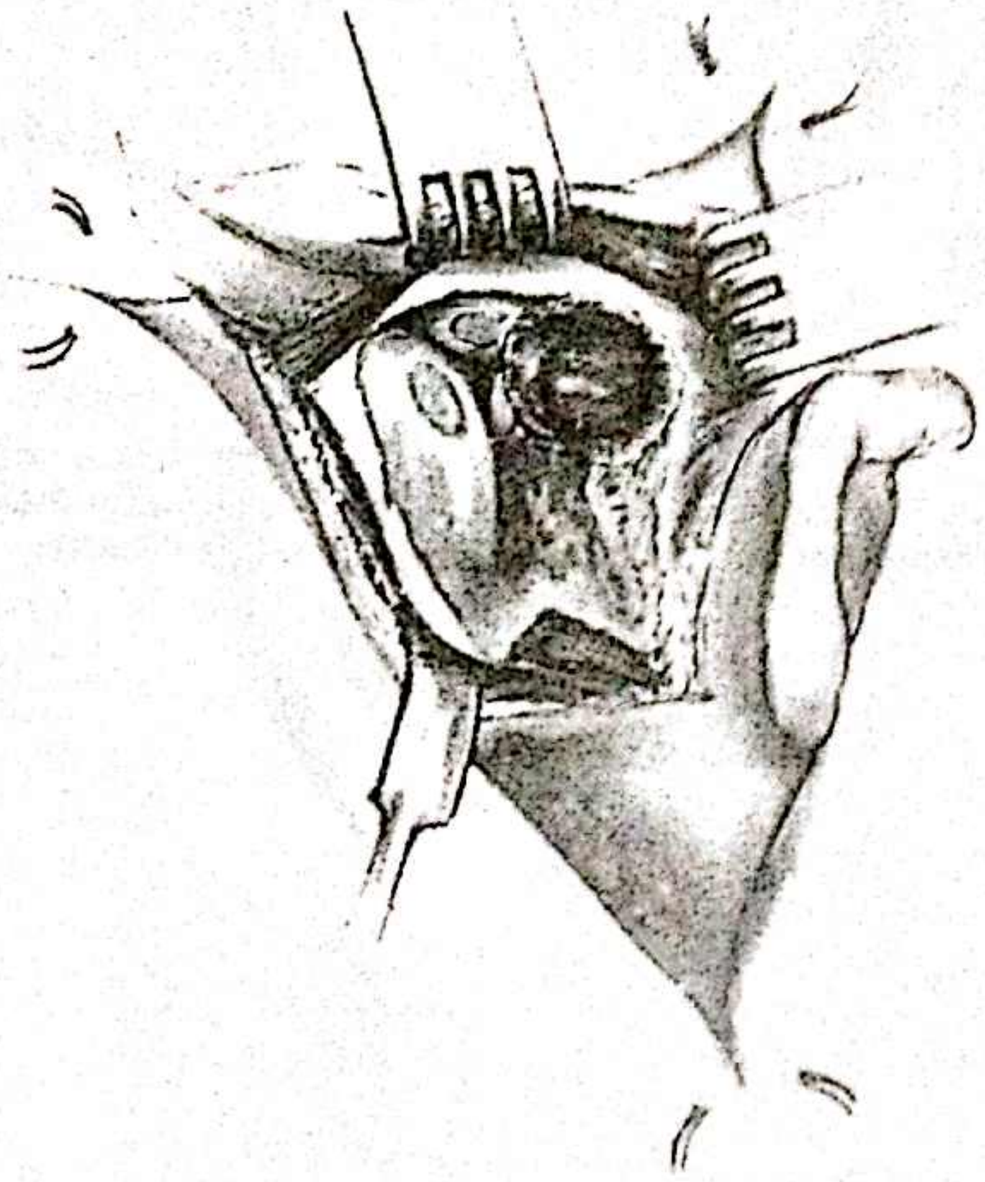


7

8

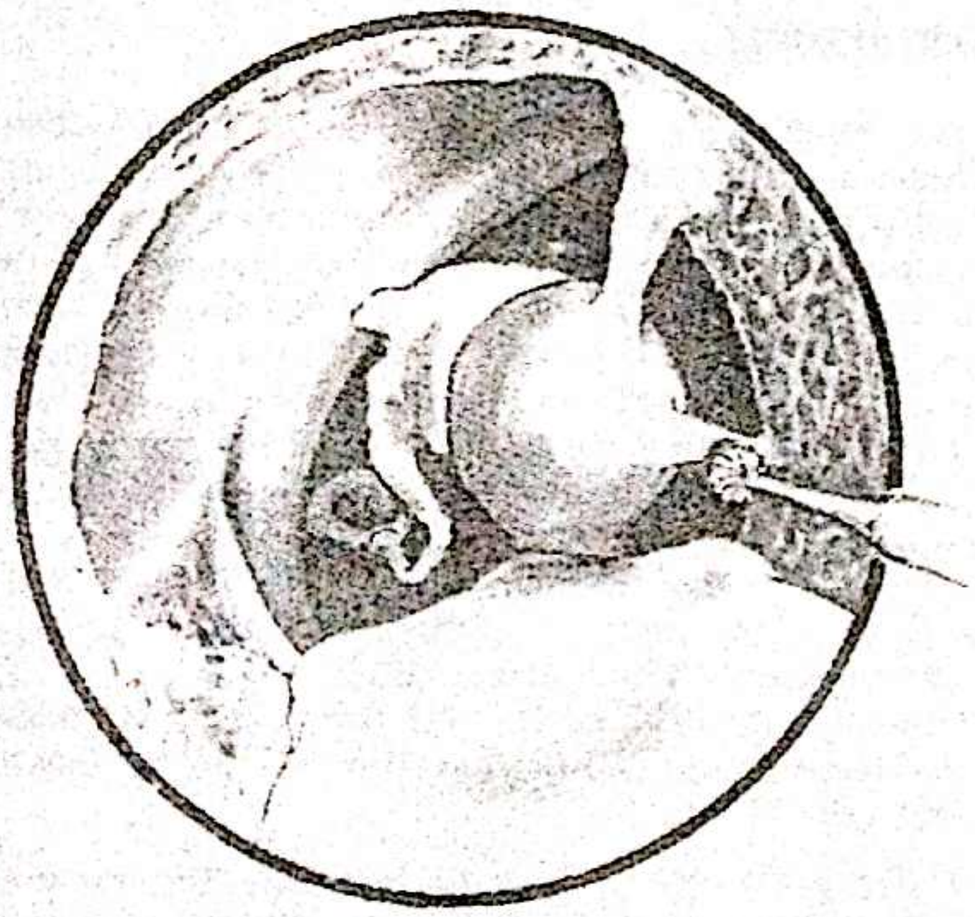
If the incus is nearly normal and attached to the stapes, the neck of the malleus is divided by burring away the bone around it and a fascial graft from the temporalis muscle is placed over it. If the incus does not articulate adequately with the stapes, the incus and malleus are removed and the bone is burred away until the stapes is adequately exposed. A type III tympanoplasty using temporalis fascia is then carried out.

If the stapes is fixed, as it may be in some of these cases, the horizontal canal is prepared for fenestration before completing the type III tympanoplasty. If desirable, the fenestration can be completed at a later date.



8

Type IV cases



9

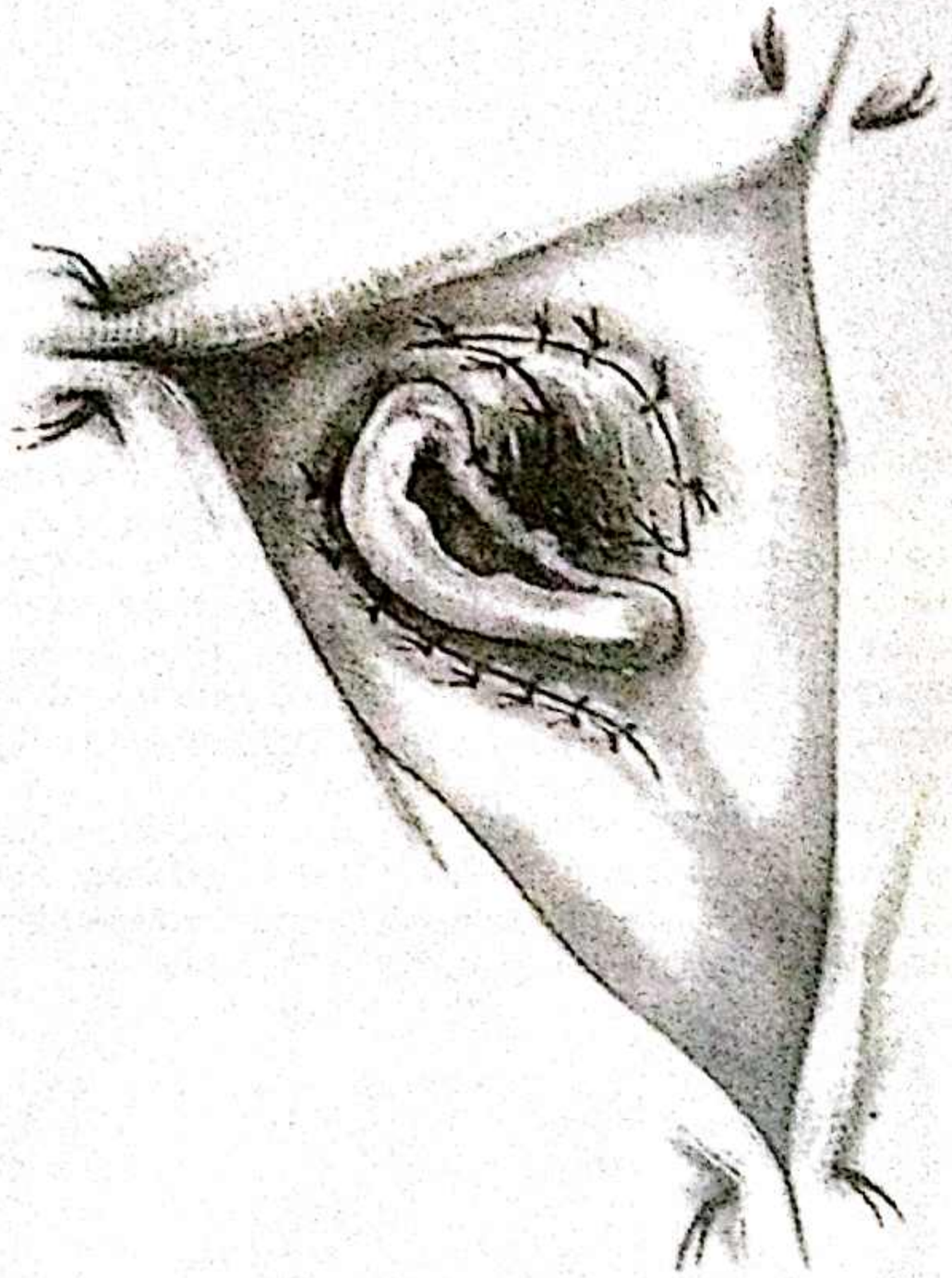
9

In these cases the ear drum can be visualized and this, together with the X-rays, will decide if the mastoid process is diseased. If not, the middle ear can be exposed as for stapedectomy. As the normal curves of the meatus are grossly exaggerated in these cases, it is as well to combine the usual stapedectomy incision with an endaural approach. Wide removal of the outer attic wall is also necessary, as very often there are bony trabeculae binding the head of the malleus to the walls of the epity:npanum. In the simple deformities where the ossicular chain is complete and only the stapes is deformed, division of these trabeculae and simple mobilization of the stapes, or stapedectomy and replacement with a suitable prosthesis is all that is necessary. In more advanced cases with gross incudal deformities, removal of the incus and wiring of the stapes to the neck of the malleus is necessary. Where the stapes is missing and its position marked by a depression in the bone, the Shea piston type of operation is possible but has not given good results in the author's hands. Better results have been obtained by fenestration of the lateral canal.

10

Closure

The Z-plasty is closed as shown. This brings the pinna and newly formed external auditory meatus back towards their normal position. The cavity is packed with BIPP gauze.



10

11

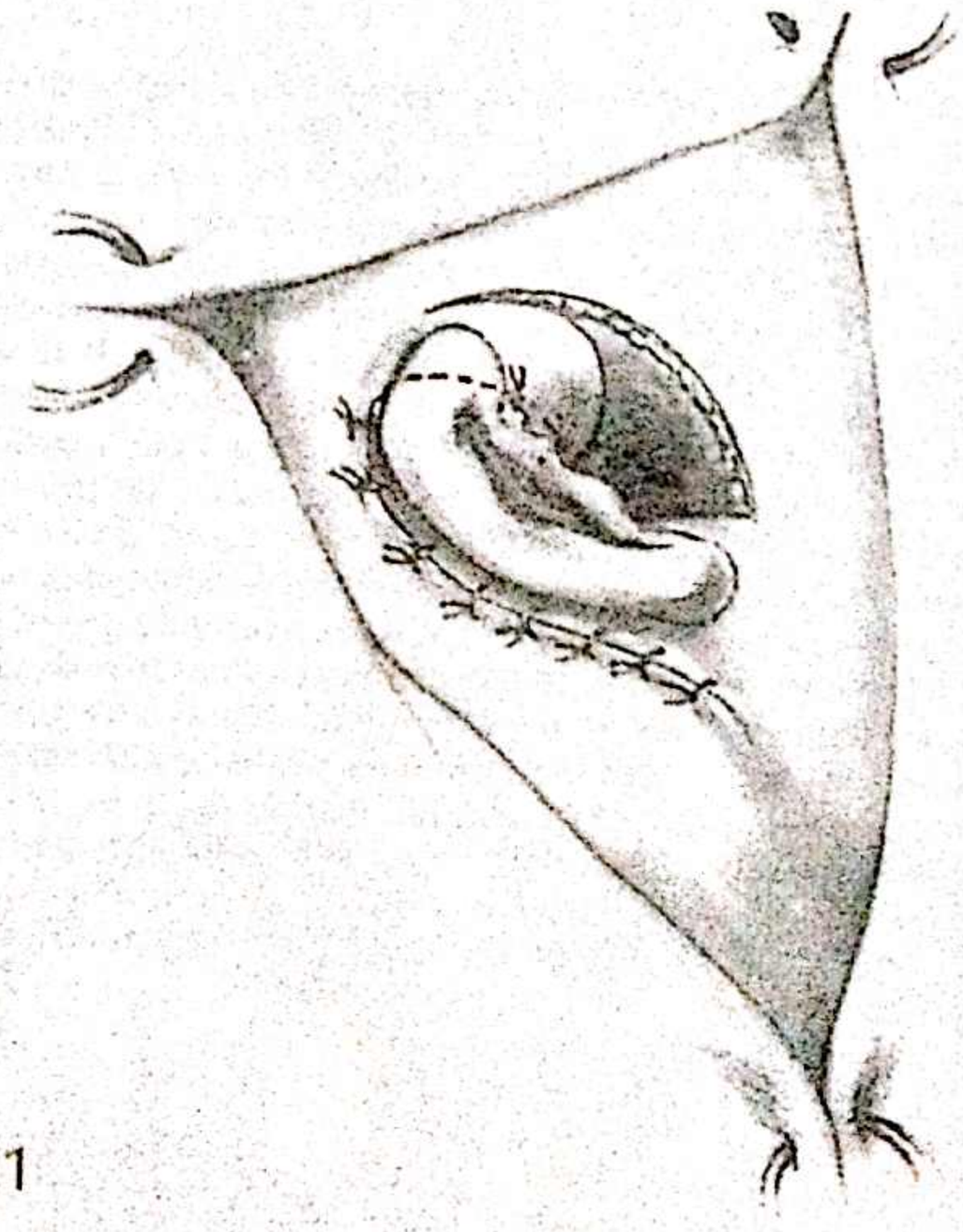
Skin grafting

One week later, again under general anaesthesia, a Thiersch graft is cut and placed over the bare area in front of the pinna and let into the cavity to cover the bare bone on the anterior aspect of the new external auditory meatus and the temporalis fascia graft. It is not allowed to overlap on to the mastoid bowl. A BIPP pack is replaced and antibiotic cover is continued for another 3 days. One week after this the BIPP pack and stitches are removed, again under a general anaesthetic. The cavity is then treated as a radical mastoid cavity.

The postoperative treatment of type IV cases in no way differs from that of stapedectomy or fenestration, whichever has been performed.

Note: The position of the VIIth nerve, the horizontal canal of the labyrinth and the anterior wall of the mastoid are interrelated.

1. The greater the degree of deformity, the more acute is the angle formed by the anterior wall of the mastoid process and the sagittal plane of the skull.
2. The greater the degree of deformity, the larger is the angle formed by the posterior end of the horizontal canal and the horizonal plane of the skull.
3. The greater the deformity, the larger is the angle formed by the VIIth nerve and the horizontal plane of the skull, the shorter is the vertical position of the nerve, the more does it approach the surface in its lower half, and the nearer to the anterior surface of the mastoid process does it leave this bone.



11

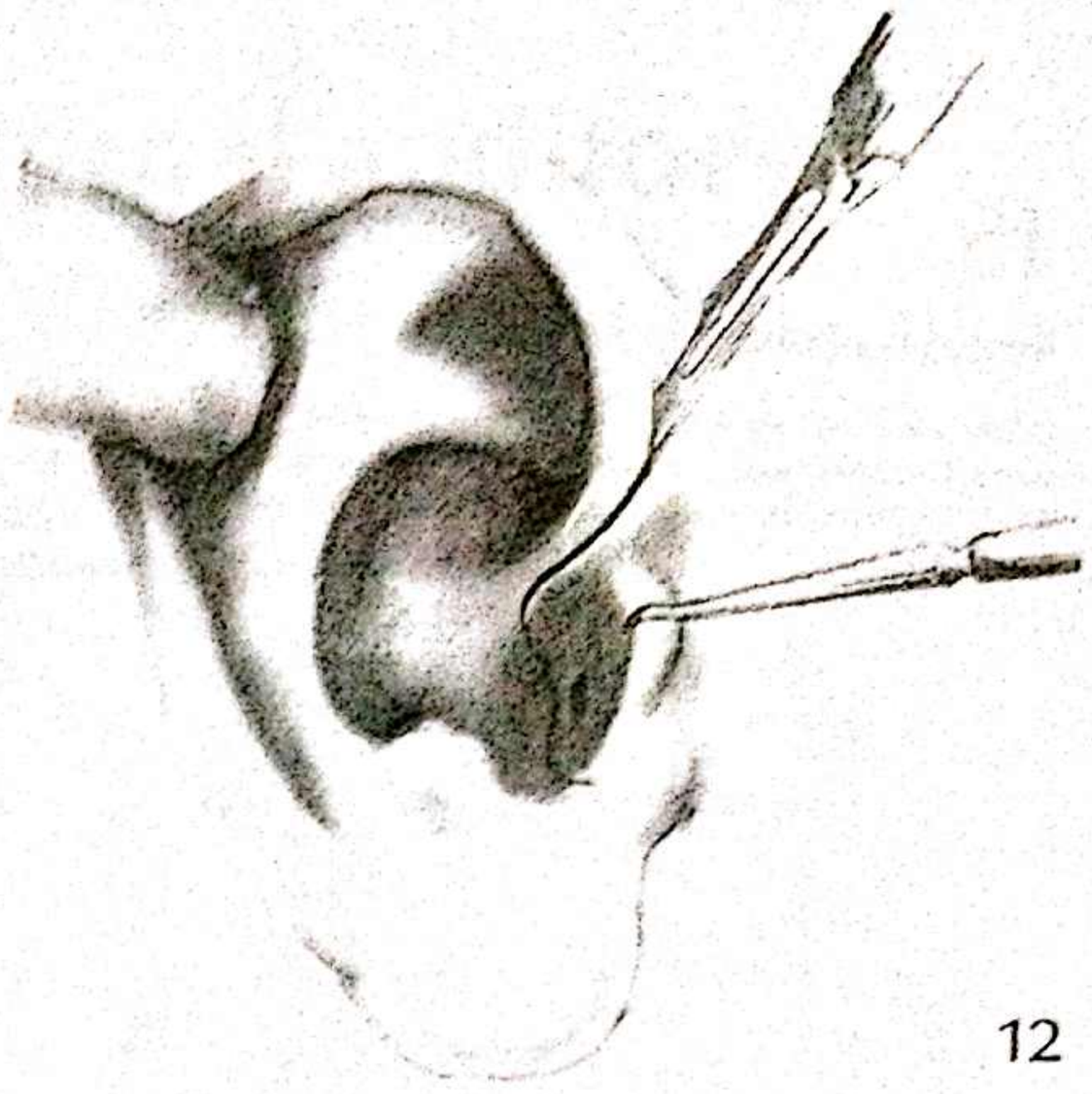
ACQUIRED ATRESIA

12

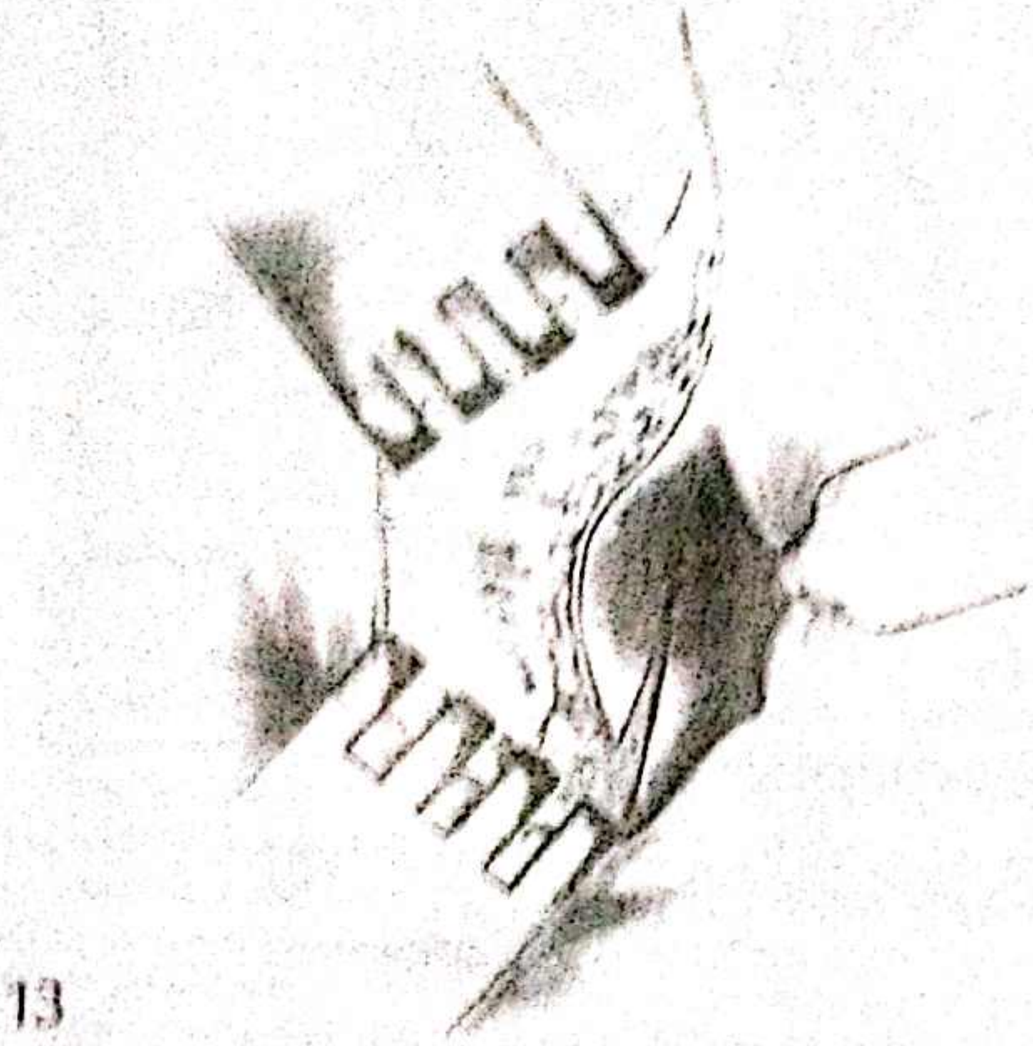
The incision

The incision is as for an endaural radical mastoidectomy, and the pinna and soft tissues are retracted.

A linear incision is made along the floor of the meatus from the drum to the edge of the mastoid incision.



12

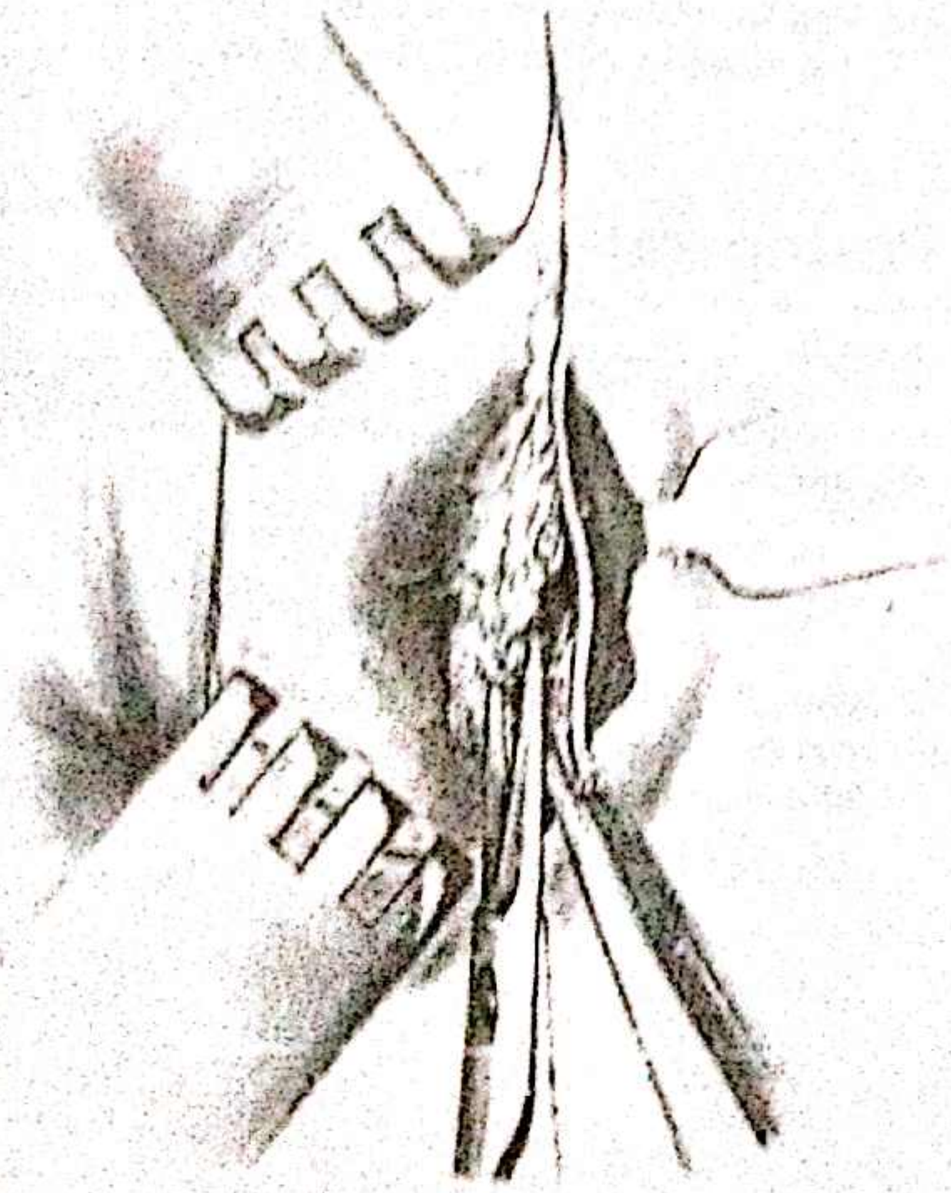


13

13 & 14

Excision of tissue

The whole of the posterior and posterosuperior skin lining of the external auditory meatus is reflected upwards and forwards, and while this is being done the thickened, almost cartilaginous, subepithelial tissues of this flap are cut away with fine scissors.



14

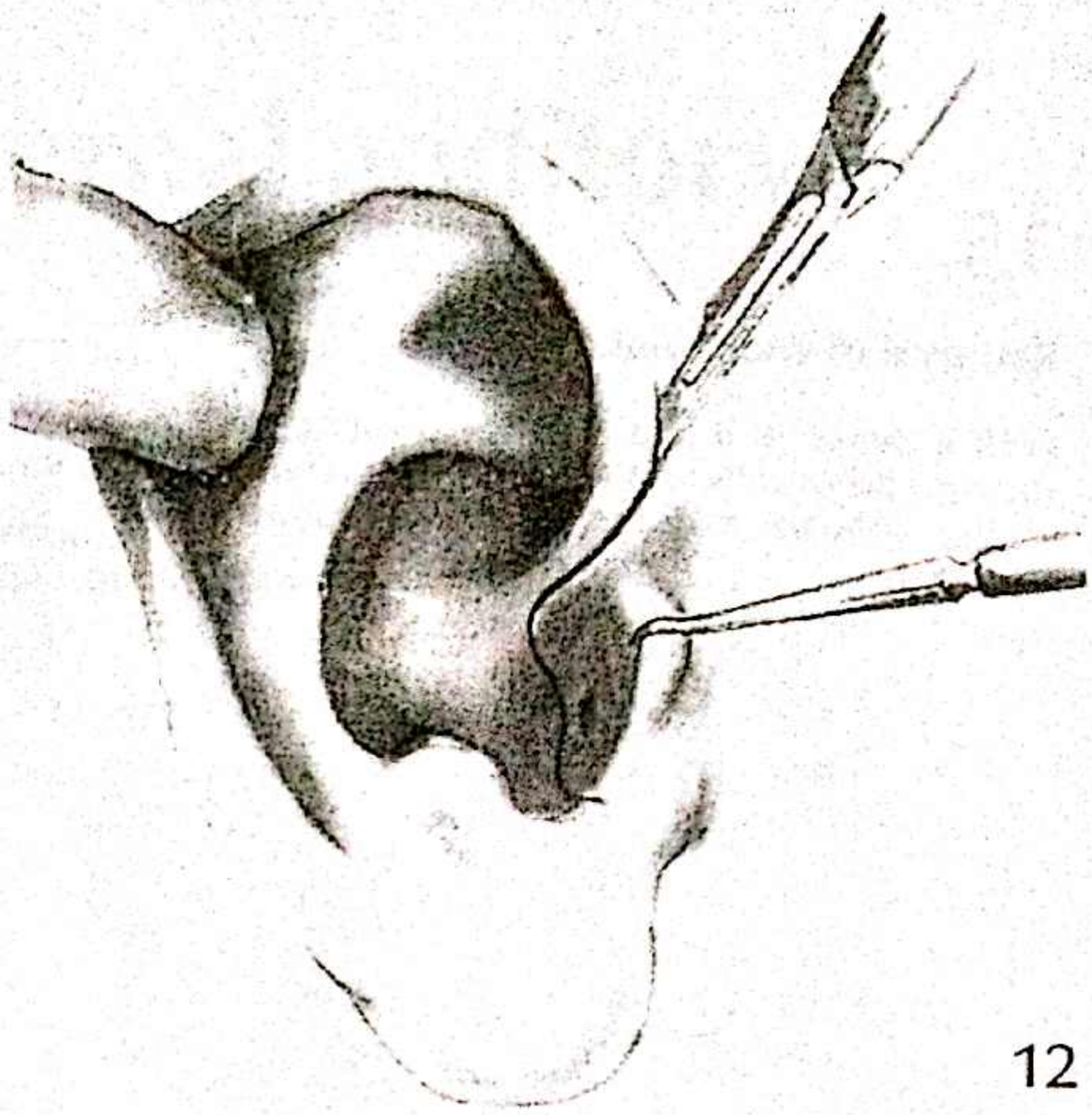
ACQUIRED ATRESIA

12

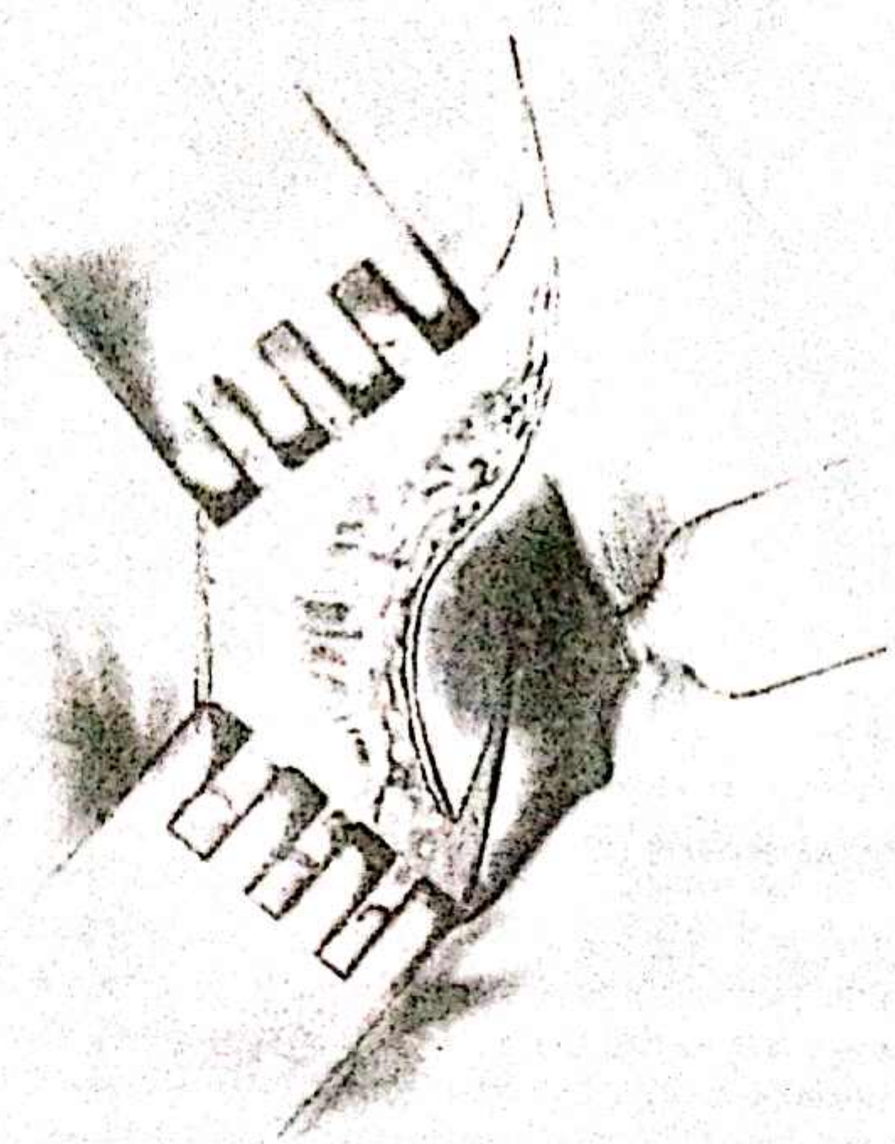
The incision

The incision is as for an endaural radical mastoidectomy, and the pinna and soft tissues are retracted.

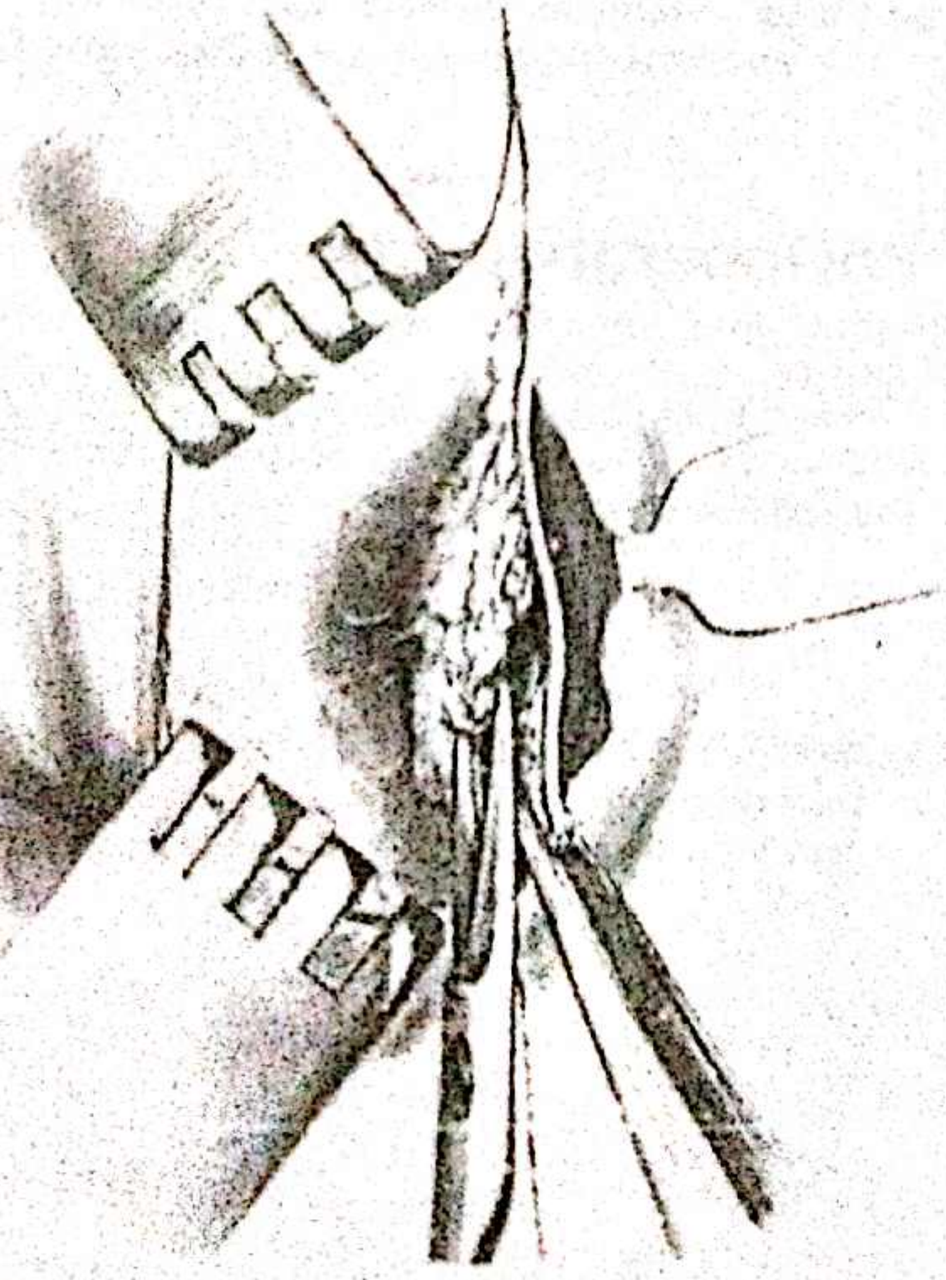
A linear incision is made along the floor of the meatus from the drum to the edge of the mastoid incision.



12



13



14

13 & 14

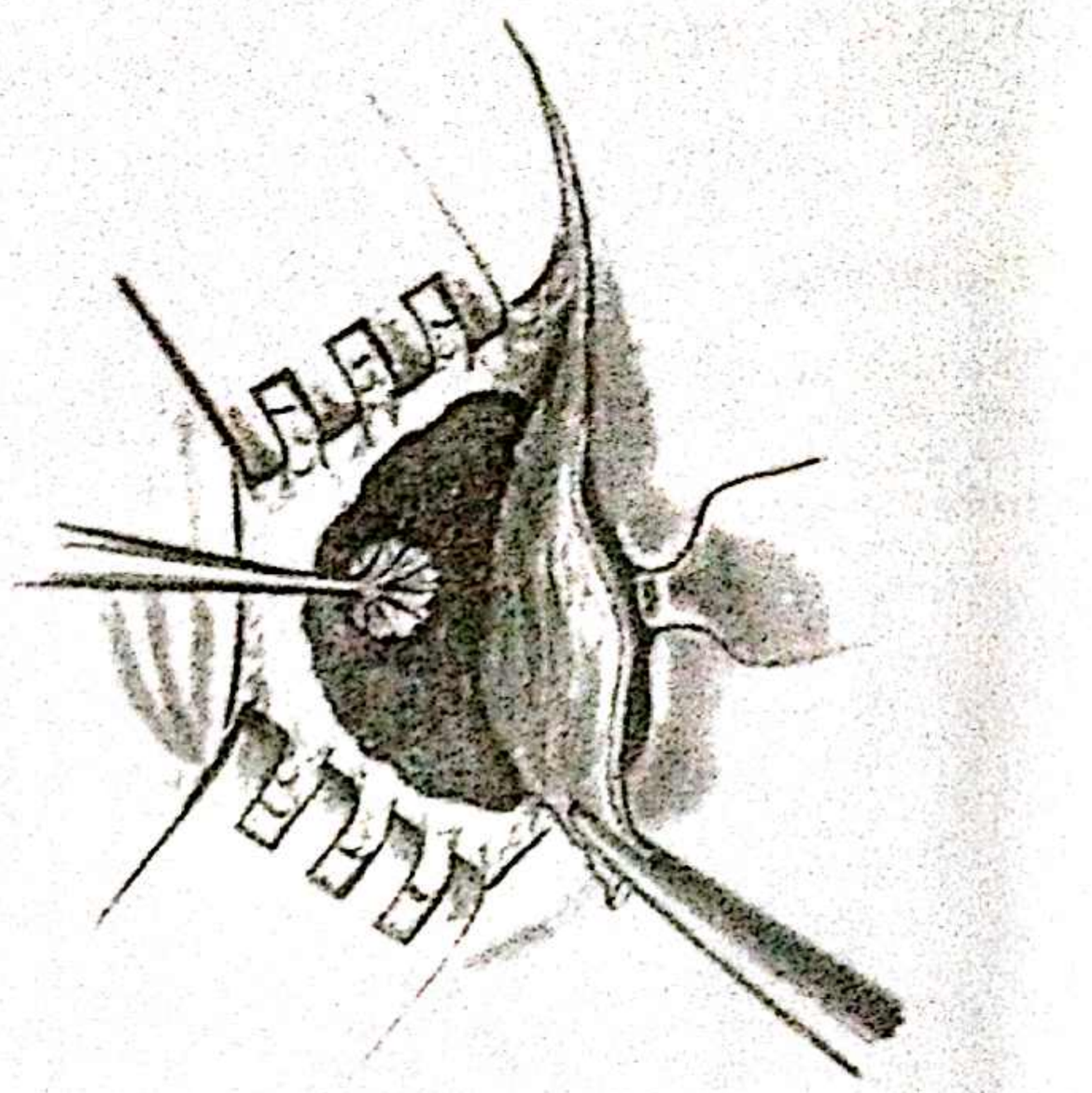
Excision of tissue

The whole of the posterior and posterosuperior skin lining of the external auditory meatus is reflected upwards and forwards, and while this is being done the thickened, almost cartilaginous, subepithelial tissues of this flap are cut away with fine scissors.

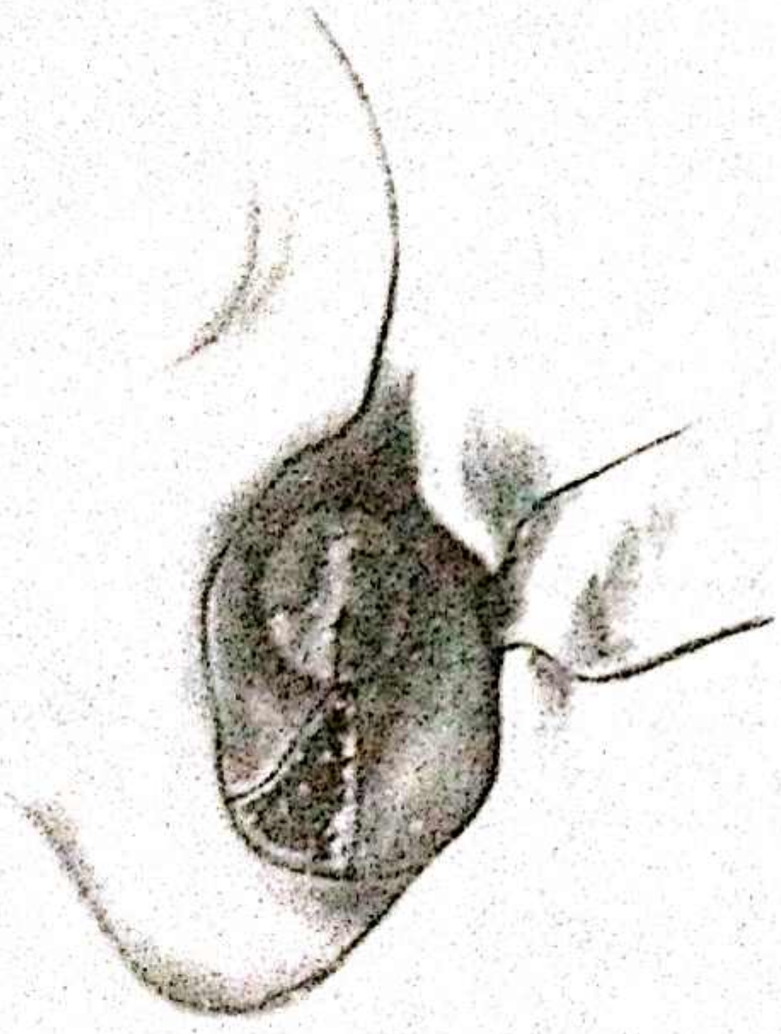
15

Removal of endomeatal spine

With a dental drill and burr the posterior and postero-superior bony walls of the meatus are widened right down to the annulus and the inferior endomeatal spine is removed.



15



16

16

Replacement of flap

The flap is put back into position and packed down with Gelfoam. After this procedure a bare area of bone is always left in the floor of the meatus along the line of the original incision. No attempt to graft this should be made. There must be no interference with the anterosuperior pedicle of the flap as this will jeopardize its blood supply and lead to subsequent necrosis.

The endaural radical incision is then closed.

Postoperative care

The Gelfoam is removed by suction at the end of 1 week, and suction should be repeated at weekly intervals until the area is dry.

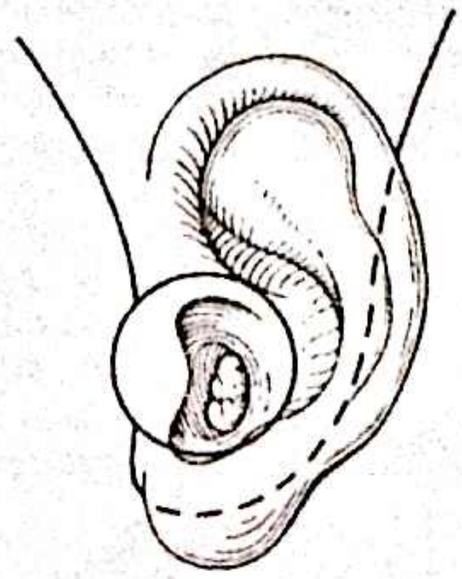
Illustrations by D. R. Purnell

Resection of the external auditory canal

John S. Lewis MD, FACS
Associate Professor in Otolaryngology, Columbia University;
Chief, Ear, Nose and Throat Service, Roosevelt Hospital, New York;
Associate Attending Surgeon, Head and Neck Service, Memorial Hospital, New York, USA

Indication

Resection of the external auditory canal is indicated for small tumours confined to the external auditory canal and not involving the ear drum. There should be at least a 0.5 cm margin between the lesion and the ear drum and no radiographic evidence of bony invasion of the mastoid.



1

The operation

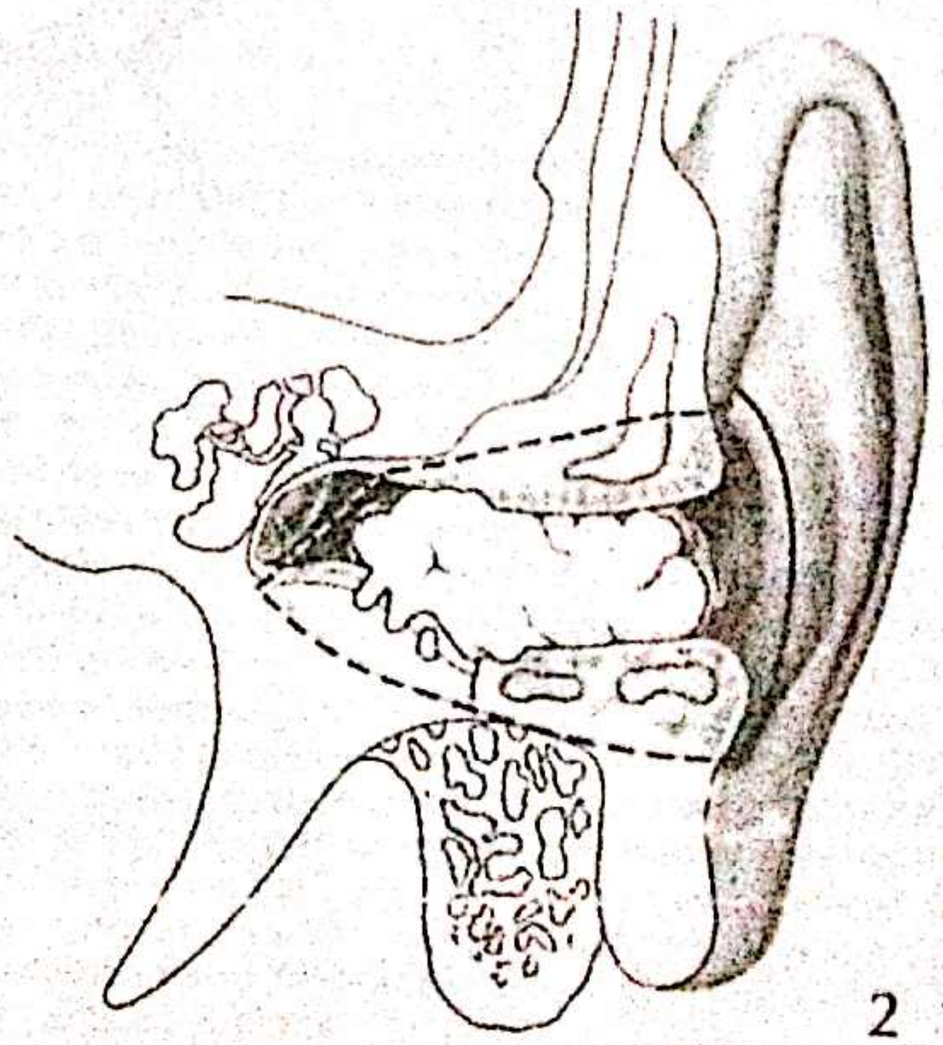
1

The incision

A U-shaped incision is made as shown. Skin, superficial fascia, temporal muscle and superficial parotid are transected and the flap is elevated from below.

2

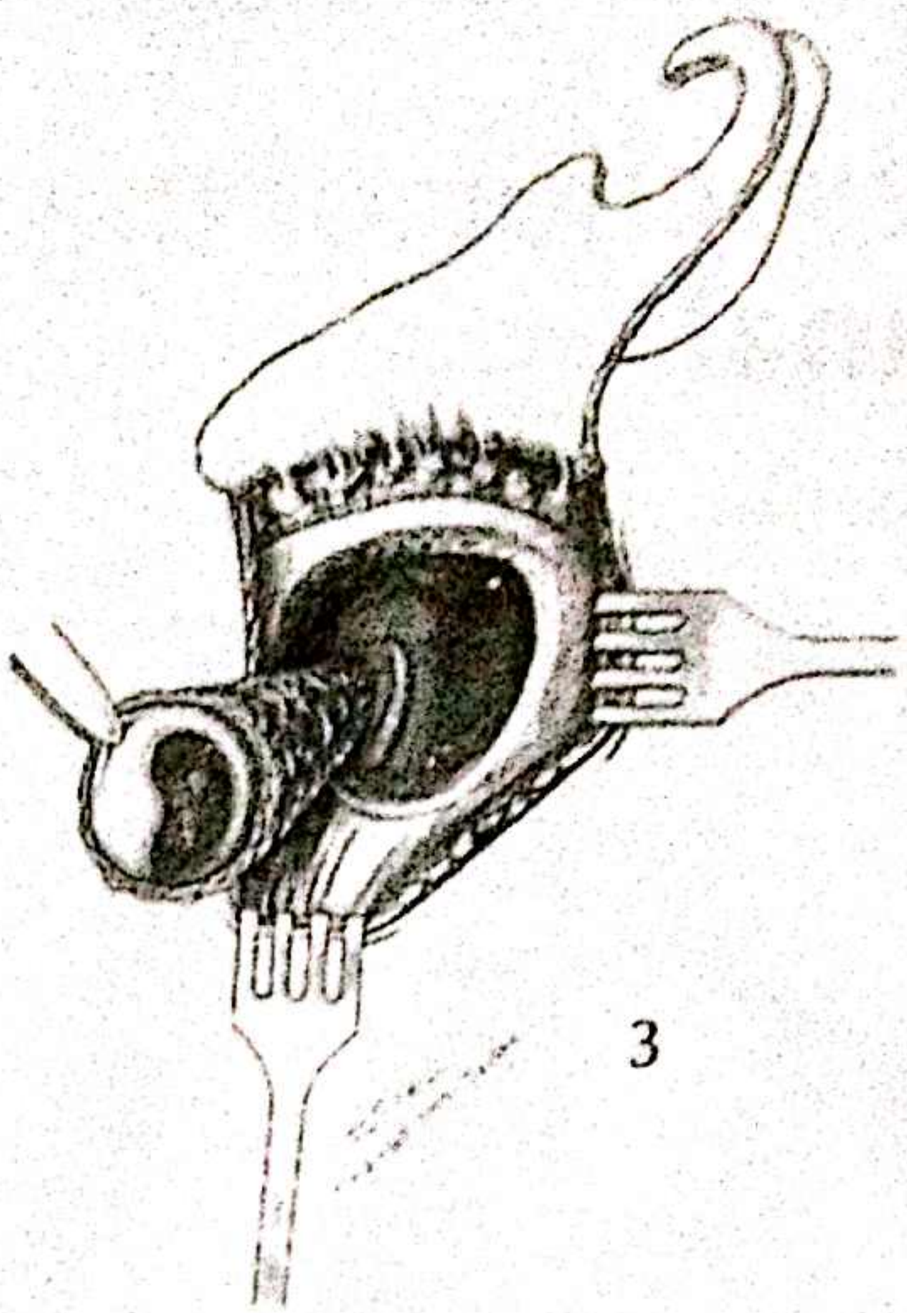
The external auditory canal is transected at the level of the external auditory meatus and the flap elevated for a distance of 4 cm above the external auditory canal



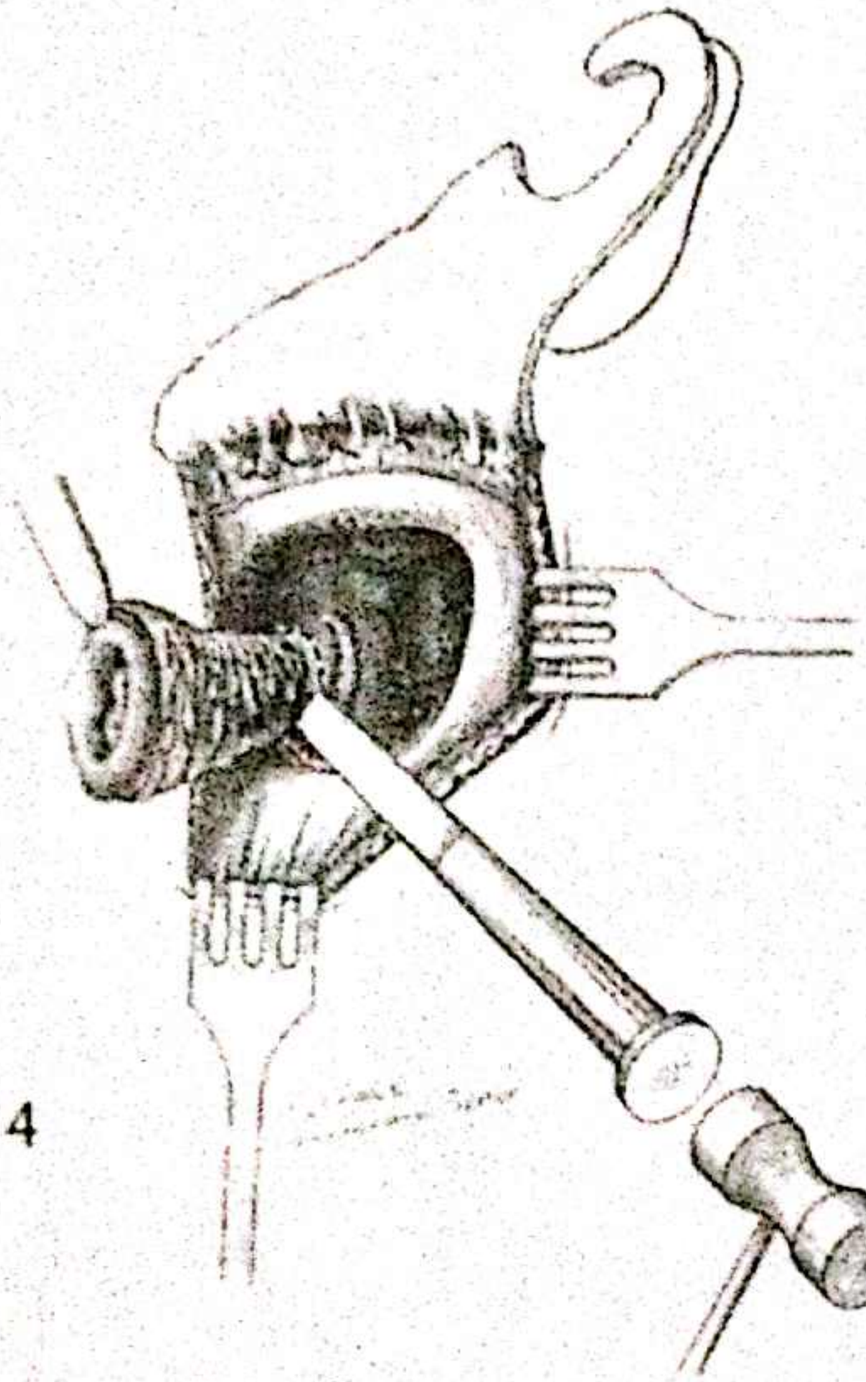
2

3

The mastoid is skeletonized in the usual manner. A high-speed air drill is used to carry out a simple mastoidectomy with exposure of the facial canal. The facial nerve is exposed with the use of the operating microscope and may be retracted out of the field if necessary. The canal is then excised anteriorly in close proximity to the temporomandibular joint and inferiorly to the level of the ear drum.



3



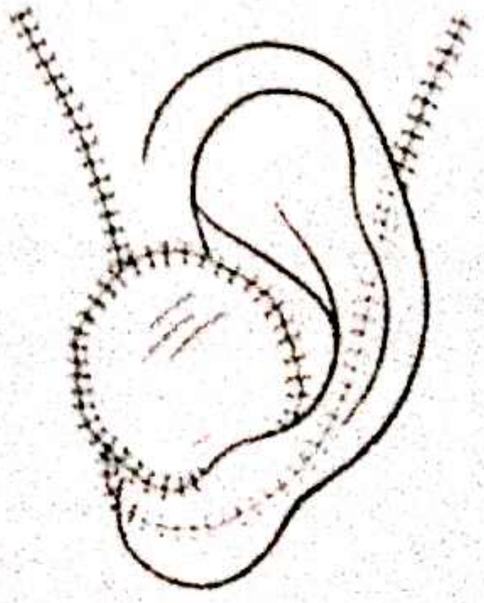
4

4

The complete circumferential excision is then carried out with an osteotome and Mayo scissors.

5

A split thickness skin graft of about 0.4 mm (16/1000 inches) is taken from the thigh with an electric dermatome and the donor site covered with Zeroform gauze. The skin graft is sutured circumferentially and inverted into the auditory canal so as to form the lining of the new mastoid canal. The canal is packed with Vaseline gauze immersed in bacitracin ointment and an external dressing is applied. The packing is kept in place for 5–7 days, after which time the sutures are removed.



5

Illustrations by Gillian Lee

Myringotomy

Joselen Ransome MB, BS, FRCS
Consultant Otolaryngologist, Charing Cross and Metropolitan Ear, Nose and Throat Hospitals, London, UK

Indications

By far the most common indication for myringotomy is secretory otitis media (SOM), (serous otitis media, seromucinous otitis media) which has failed to respond to medical or other treatment. It is performed to confirm the diagnosis, to aspirate fluid, and when necessary to insert a ventilation tube (VT). The purpose of the latter is to establish adequate aeration of the middle ear cleft, with consequent reversion of the pathological changes in the middle ear mucosa. The technique of inserting a hollow device through the tympanic membrane for this purpose was first described by Politzer in 1883[1]; not surprisingly, it was not until Armstrong[2] devised a plastic flanged tube in 1954, when the era not only of aseptic surgery but also of the operating microscope had arrived, that the procedure gained widespread acceptance. At the same time secretory otitis media became more widely recognized and the incidence appeared to increase, so that myringotomy and ventilating tube (grommet) insertion is now one of the most commonly performed of all operations throughout the world. Gibb[3] found that in the Tayside area of Scotland the insertion rate for all age groups was 1.43 per 1000, while in patients of 14 years and under it was 4 per 1000. Paradise[4] estimated the worldwide insertion rate to be in the region of 2 million annually.

In SOM a VT is usually inserted when other treatments have failed. These include adenoidectomy; administration of antibiotics, antihistamines, decongestants and carbocisteine; Eustachian tube inflation by various methods; and attention to disease of the nose, sinuses, nasopharynx and occasionally tonsils. Some surgeons perform myringotomy routinely at the same time as adenoidectomy when SOM is suspected and insert a VT if thick tenacious fluid is found. The purpose is to avoid a second surgical procedure should adenoidectomy alone fail to allow the ear to clear thick secretions; additionally, the immediate hearing gain is educationally important in school children.

Myringotomy with insertion of a VT may also be required in the poorly ventilated middle ear cleft where fluid is absent. Such patients may have retraction of the whole pars tensa, which if persistent may result in adhesion to the promontory and hearing impairment; or there may be retraction pockets in the tympanic membrane, desquamation in which may ultimately lead to cholesteatoma. Reversal of retraction and retraction pockets after insertion of VTs commonly occurs. On rare occasions myringotomy may be indicated in acute suppurative otitis media if there is bulging of the tympanic membrane and persistence of pain and pyrexia despite adequate antibiotic treatment.

It may also be performed in cases of suspected malignant disease of the nasopharynx. Fluid aspirated can be sent for cytology and may show malignant cells.

Preoperative

Anaesthesia

Premedication is required in all patients undergoing general anaesthesia and may be used without atropine in apprehensive patients who are to have local anaesthesia.

Some form of anaesthesia must be used. General anaesthesia is mandatory in all cases of acute suppurative otitis media. It is also necesssary in most children and some adults with secretory otitis media. Local anaesthesia can be used in older children and adults, particularly in the small minority in whom repeated insertion of grommets is required because of frequent recurrences. Very satisfactory local anaesthesia can be induced by subcutaneous injection of 2 per cent lignocaine (lidocaine) at four points in the external auditory meatus just deep to the hair-bearing area. If the injections follow each other so that adjacent quadrants are injected, only the first needle-prick will be felt. After the myringotomy incision is made, a few drops of 5 per cent lignocaine can be allowed to run into the middle ear, so that the promontory is anaesthetized and the patient will not move his head if a sucker should touch it.

The operation

The operation *must* be carried out under magnification if the myringotomy and grommet insertion are to be done correctly and complications avoided. Satisfactory illumination is also vital. Whenever possible the Zeiss operating microscope should be used, as it provides ideal magnification and illumination. Full theatre facilities and rigorous aseptic technique are required, whether the procedure is carried out under local or general anaesthesia.

1

The patient is placed supine on the operating table with the head turned to one side resting in a ring.

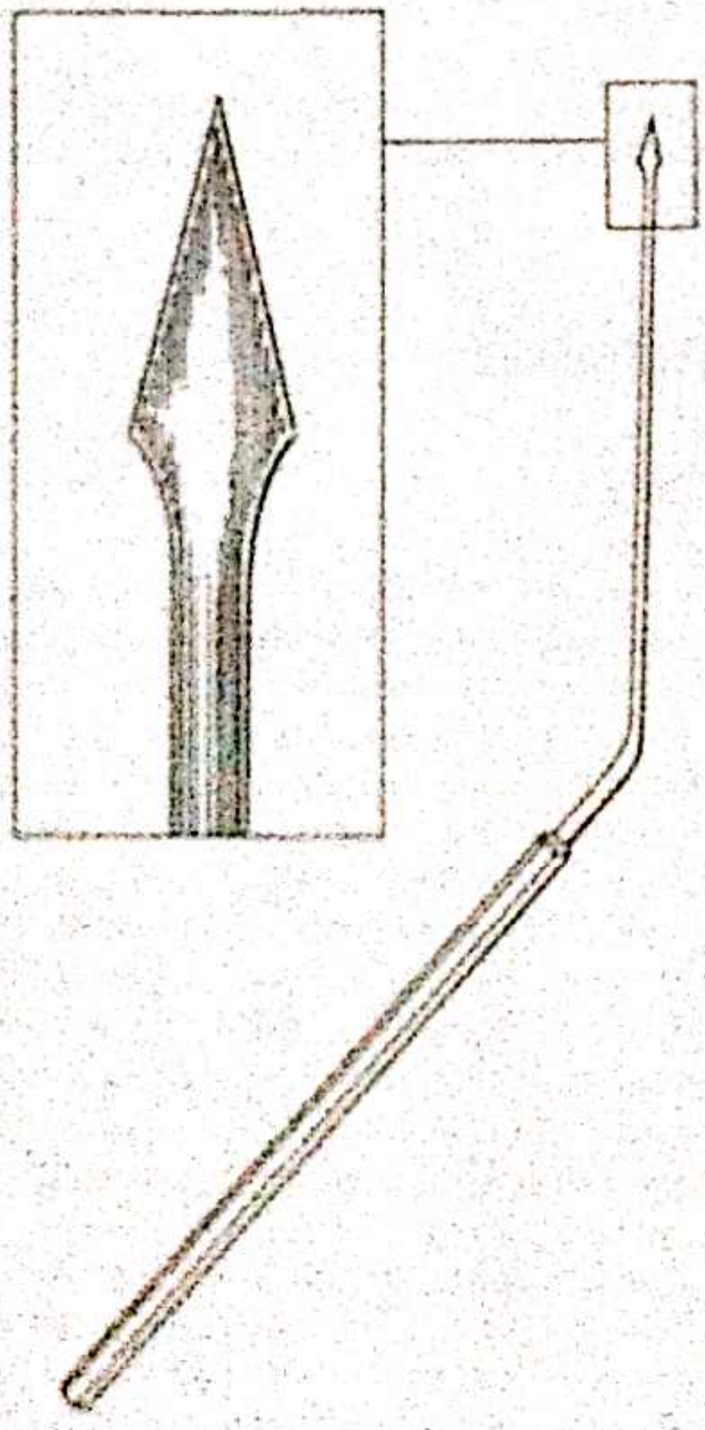
1

Skin preparation

The pinna and adjacent skin are cleansed with any suitable agent, e.g. 1 per cent chlorhexidine (Hibitane) in spirit. However, care is taken *not* to allow the solution to run down the canal. The epithelium of the deeper parts of the canal and of the tympanic membrane does not contain pathogenic bacteria. Sterile towels are applied, leaving only the pinna uncovered. If the patient is having a local anaesthetic the lignocaine is now injected.

The incision

The Zeiss microscope is brought into position, the largest matt black operating aural speculum which will fit the canal is inserted and, using ×6 magnification, the microscope is focused on the tympanic membrane. In patients with secretory otitis media the position of the head is adjusted so that the anterior half of the pars tensa is clearly seen while in those with acute suppurative otitis media it is adjusted so that the posterior half is best seen, as this is the area where the bulging will be.



2

2

Using a sharp myringotome with an angled hand-piece the drumhead is incised, taking great care not to pass the tip of the myringotome deeply into the middle ear cavity, as this could damage underlying structures (see 'Complications', page 37).

The site of the incision depends on the type of otitis media.

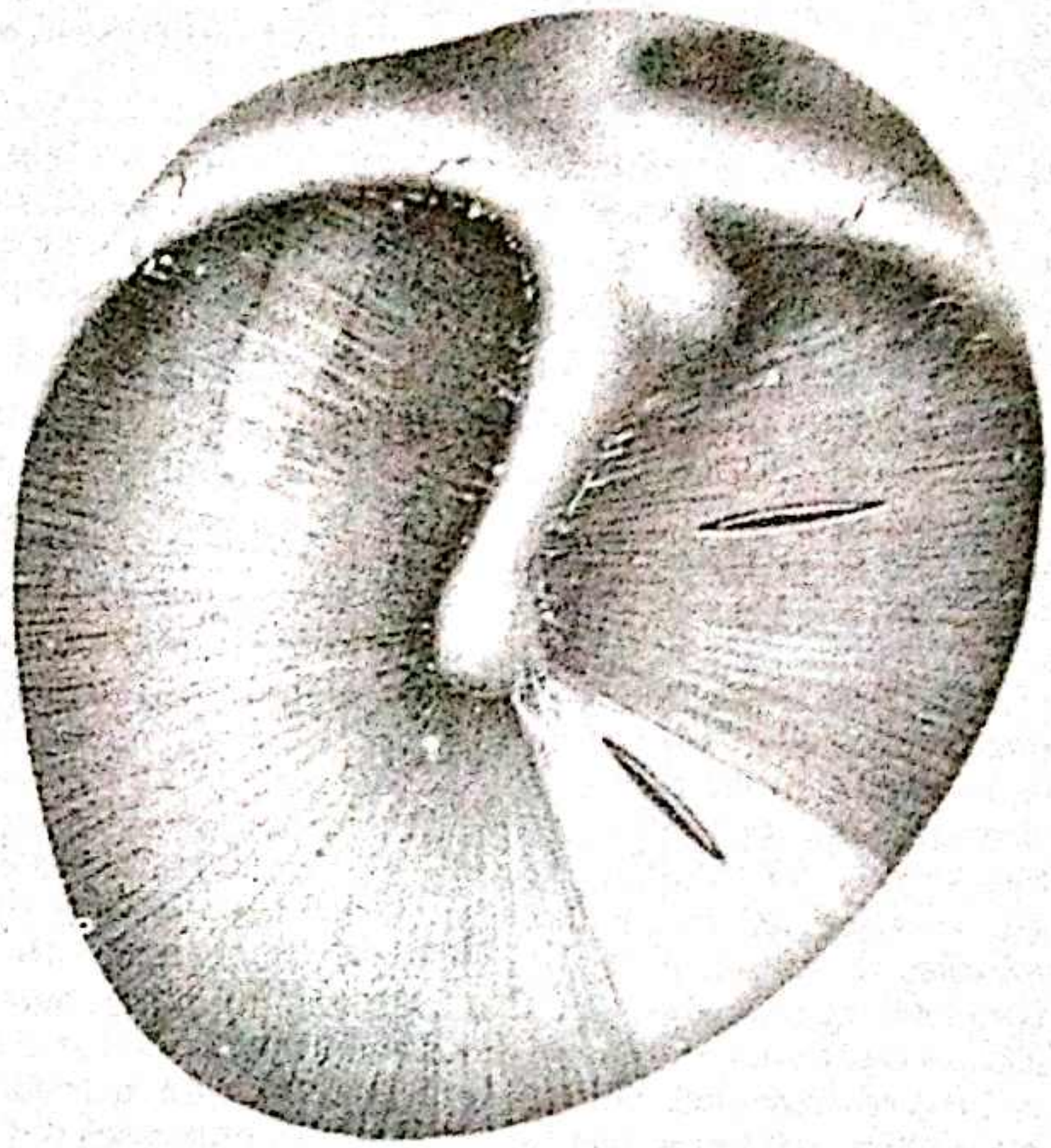
Secretory otitis media

3

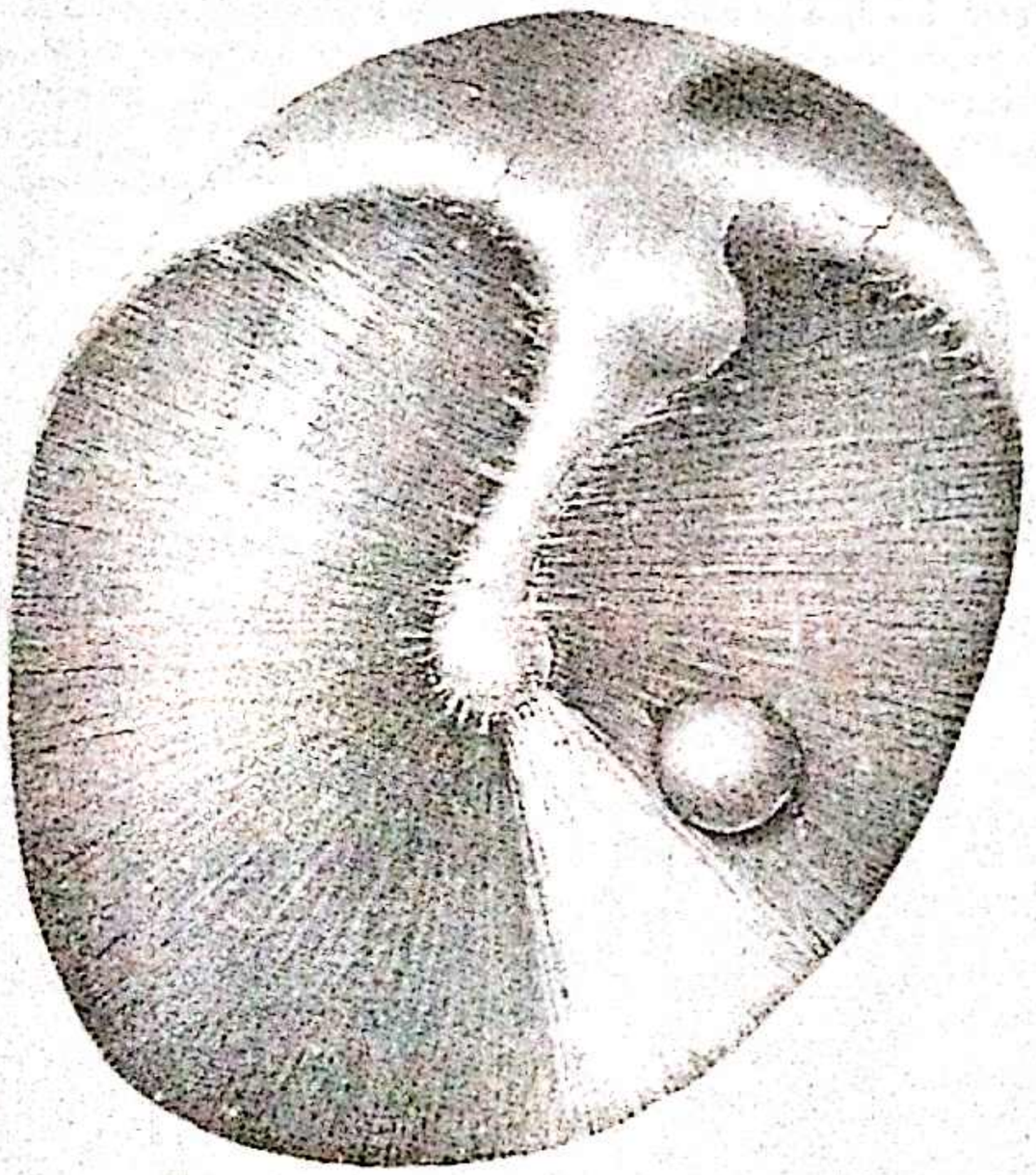
In secretory otitis media a small *radial* incision is made in the antero-inferior or anterosuperior quadrant; the latter is more appropriate when long-term ventilation is required, since one factor in tube extrusion is epithelial migration and heaping of epithelial debris to one side of the tube – this is slower in the anterosuperior segment. A radial incision, which separates rather than cuts across the fibres of the middle layer of the tympanic membrane, heals more readily and with less scarring if no tube is required; if a tube is inserted, a radial incision offers less of a barrier to epithelial migration (which takes place medially) so that extrusion is delayed as less heaping occurs.

The length of the incision depends on the type of VT to be used. With the commonly used Shepard VT, and others with small circular inner flanges, the incision should be the same length as the external diameter of the inner flange. If it is too long the neck of the tube will not be 'gripped' after insertion by the edges of the incision, and premature extrusion will occur. If the incision is too short, attempts to force a tube through may lead to tearing of the drumhead, especially if it is atrophic.

Some VTs designed for very long-term ventilation require a different size and site of incision (see later).



3



4

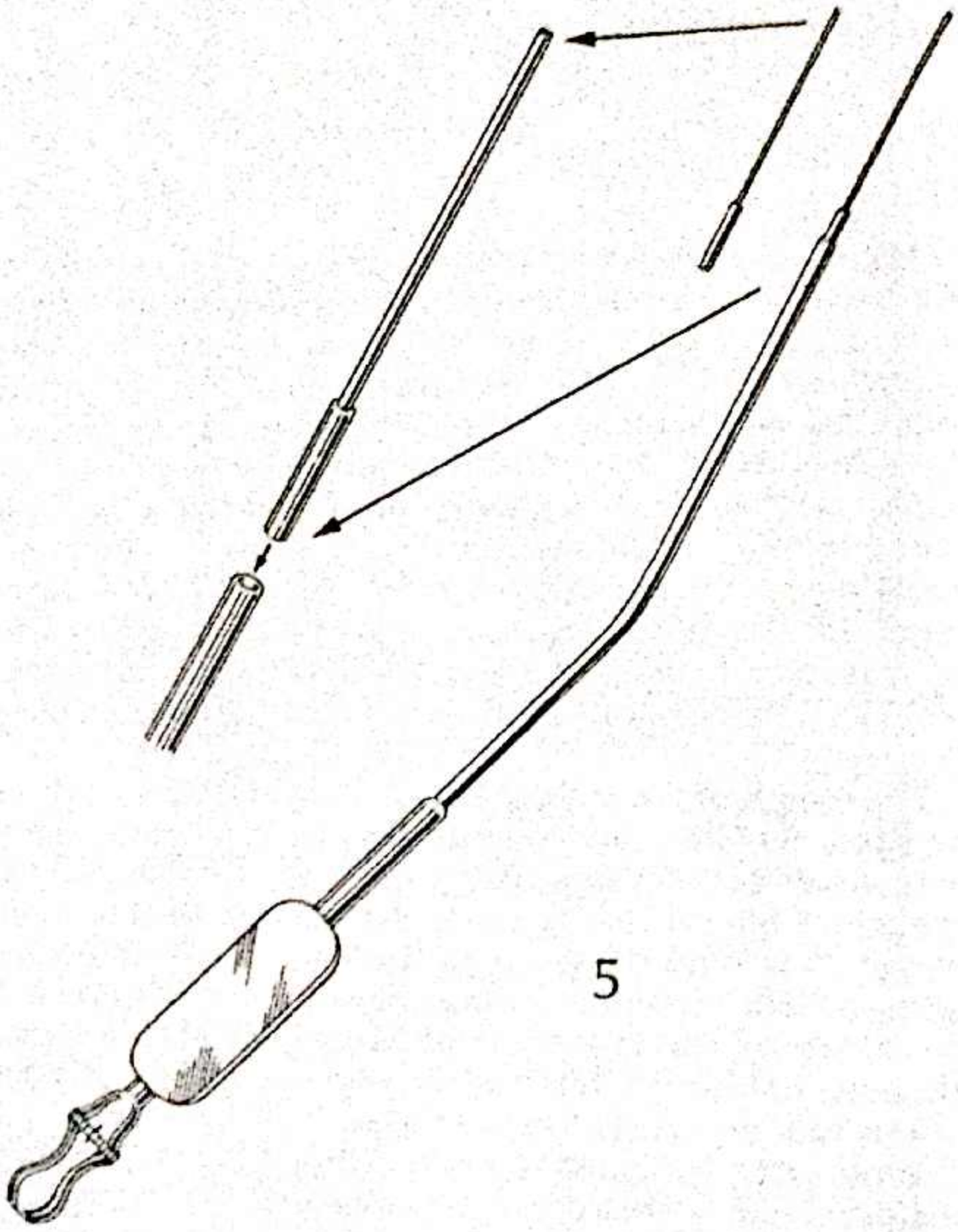
4

If thick fluid is present in the middle ear cleft under pressure, it will at once exude through the incision and be seen as a semi-transparent yellowish viscid blob. Thin serous fluid may sometimes pass through the incision, but usually it is only visible when suction is applied, when bubbles will be seen running on the deep surface of the drumhead towards the sucker tip.

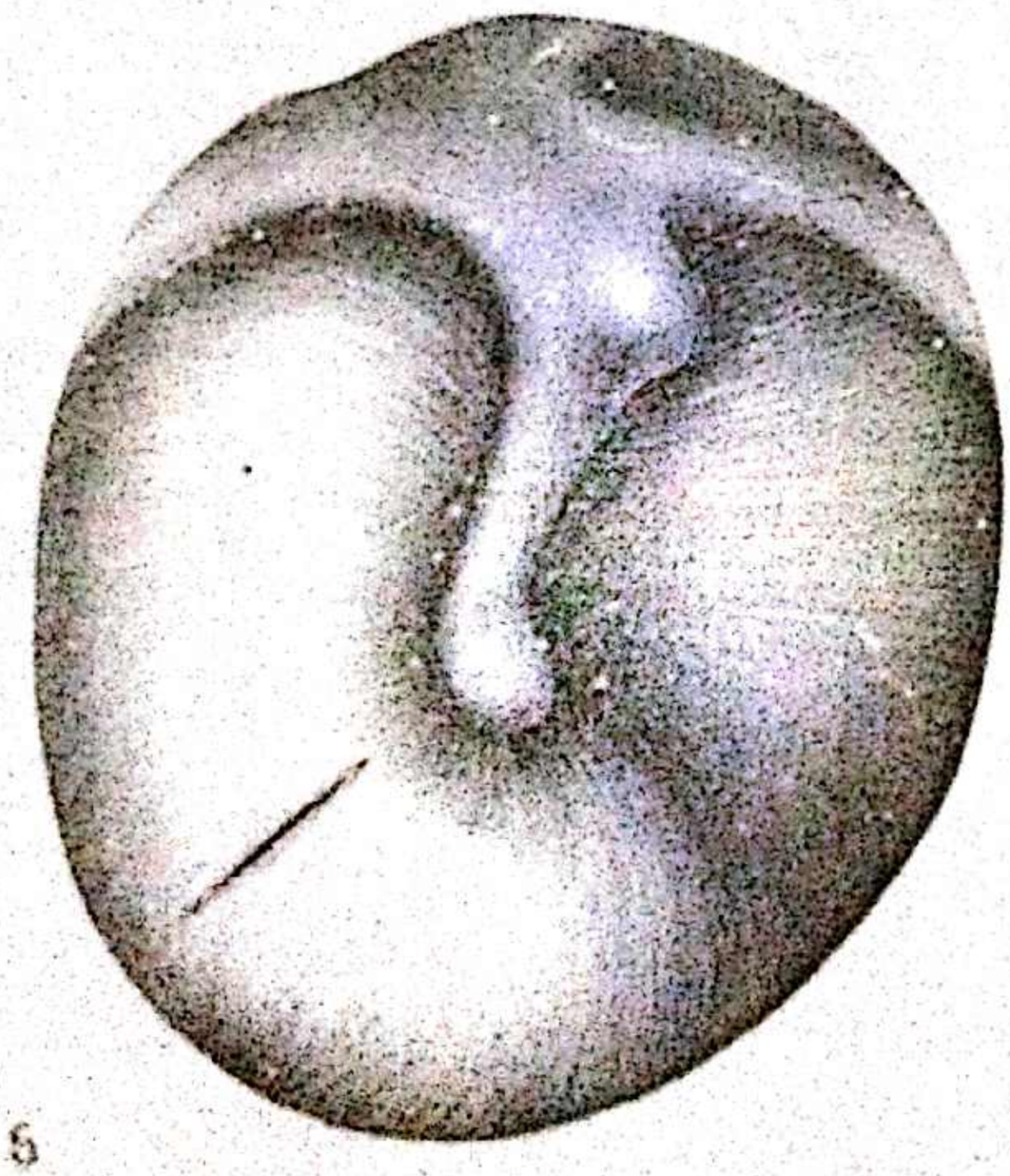
5

As much fluid as possible is sucked out by passing a fine angled sucker *just* through the incision, taking care not to enlarge the incision in the process and not to cause unnecessary bleeding or promote adhesions by scratching the middle ear mucosa.

The fluid is sometimes so viscous that it is very difficult to evacuate it all through a fine sucker. A larger bore sucker applied to the surface of the drumhead overlapping half the incision (leaving the other half free for air entry) will usually deal with most of it. Obstinate blobs can sometimes be sucked up to the edge of the incision; then grasped with fine crocodile forceps and pulled up so that a larger sucker can then be applied. Although it is desirable to evacuate all fluid completely so as to restore hearing immediately, and to avoid the risk of viscid secretions blocking a VT, this is not always possible; repeated introduction of the sucker may, by traumatizing the middle ear mucosa, do more harm than good, when weighed against the fact that residual fluid will nearly always disappear within ten days once the middle ear cleft is properly aerated. Double incisions have been recommended to help evacuation of fluid in difficult cases but in the author's view this is unnecessary and undesirable.



5



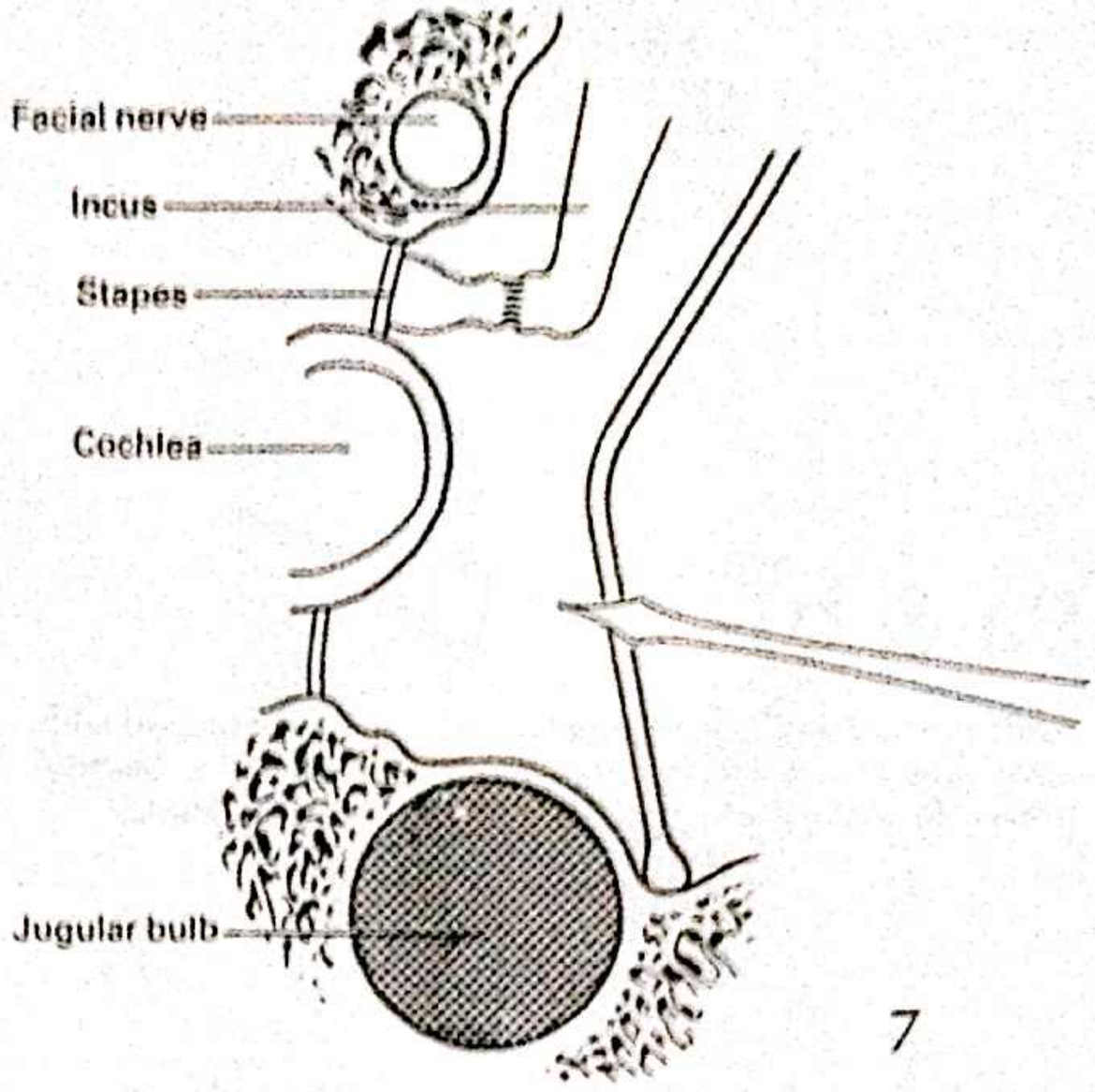
6

Acute suppurative otitis media

6

In acute suppurative otitis media (ASOM) the incision is sited postero-inferiorly.

7



7

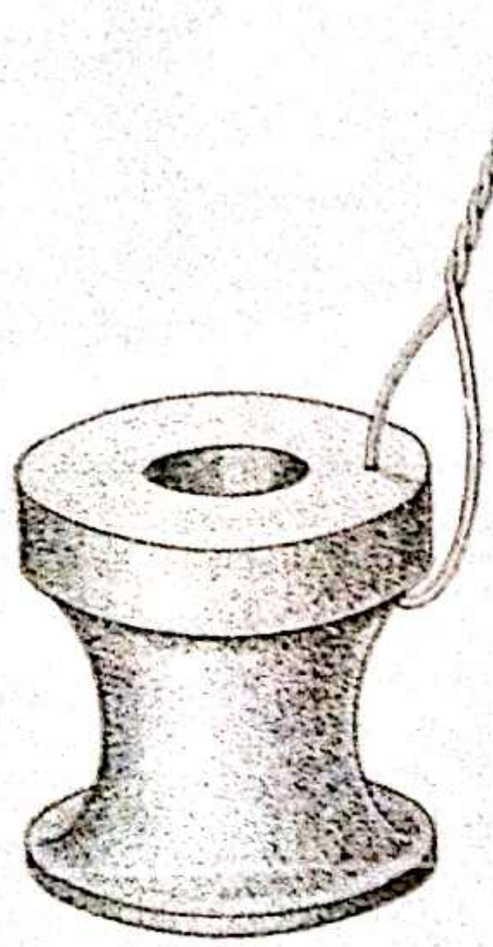
It is always the posterior half of the drumhead which bulges, and the incision must be inferior to avoid damage to the ossicular chain, facial nerve and chorda tympani.

Pus gushes out under pressure as soon as the incision is made. A swab is taken and sent for bacteriological evaluation. The incision should be about 3–4 mm. Tiny incisions tend to heal too quickly and allow pus to re-accumulate in the middle ear. VTs should not be inserted in cases of ASOM.

Choice of a ventilating tube

A large range of ventilating tubes of different materials and design is now available.

1. *Materials* For all purposes the material should ideally be completely smooth and inert, as this reduces the tendency for the lumen to become blocked by blood or secretions. Tubes made of Teflon, silicone and stainless steel are superior in this respect to polyethylene. Some designs are now available with an ultra-thin carbon coating (as sometimes used on artificial heart valves and other indwelling materials).
2. *Design* The large number of designs which have evolved reflects the attempts of otologists to solve the problems of premature extrusion and blockage of the lumen. Since the design of the tube determines the technique of insertion, some of the many tubes now in use are considered below together with their particular purpose and method of introduction.



8

Insertion of ventilating tube

Short-term ventilation

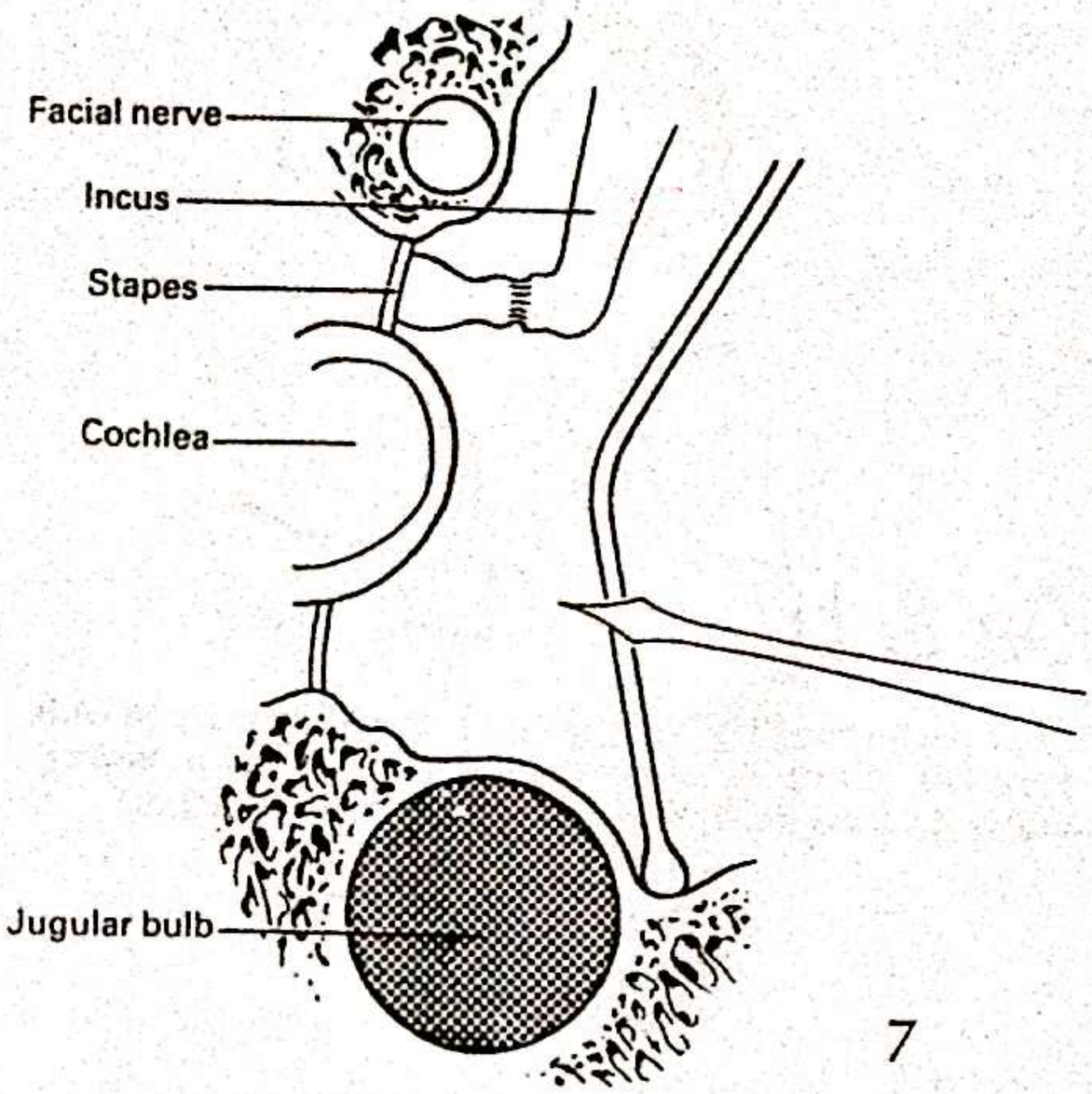
8

One of the older designs and still one of the most popular is the Shepard VT, available in Teflon or silicone with either an attached stainless steel wire or an integral tail of the same material, either of which can be cut as short as required.

7

It is always the posterior half of the drumhead which bulges, and the incision must be inferior to avoid damage to the ossicular chain, facial nerve and chorda tympani.

Pus gushes out under pressure as soon as the incision is made. A swab is taken and sent for bacteriological evaluation. The incision should be about 3–4 mm. Tiny incisions tend to heal too quickly and allow pus to re-accumulate in the middle ear. VTs should not be inserted in cases of ASOM.



7

Choice of a ventilating tube

A large range of ventilating tubes of different materials and design is now available.

1. *Materials* For all purposes the material should ideally be completely smooth and inert, as this reduces the tendency for the lumen to become blocked by blood or secretions. Tubes made of Teflon, silicone and stainless steel are superior in this respect to polyethylene. Some designs are now available with an ultra-thin carbon coating (as sometimes used on artificial heart valves and other indwelling materials).

2. *Design* The large number of designs which have evolved reflects the attempts of otologists to solve the problems of premature extrusion and blockage of the lumen. Since the design of the tube determines the technique of insertion, some of the many tubes now in use are considered below together with their particular purpose and method of introduction.

8

Insertion of ventilating tube

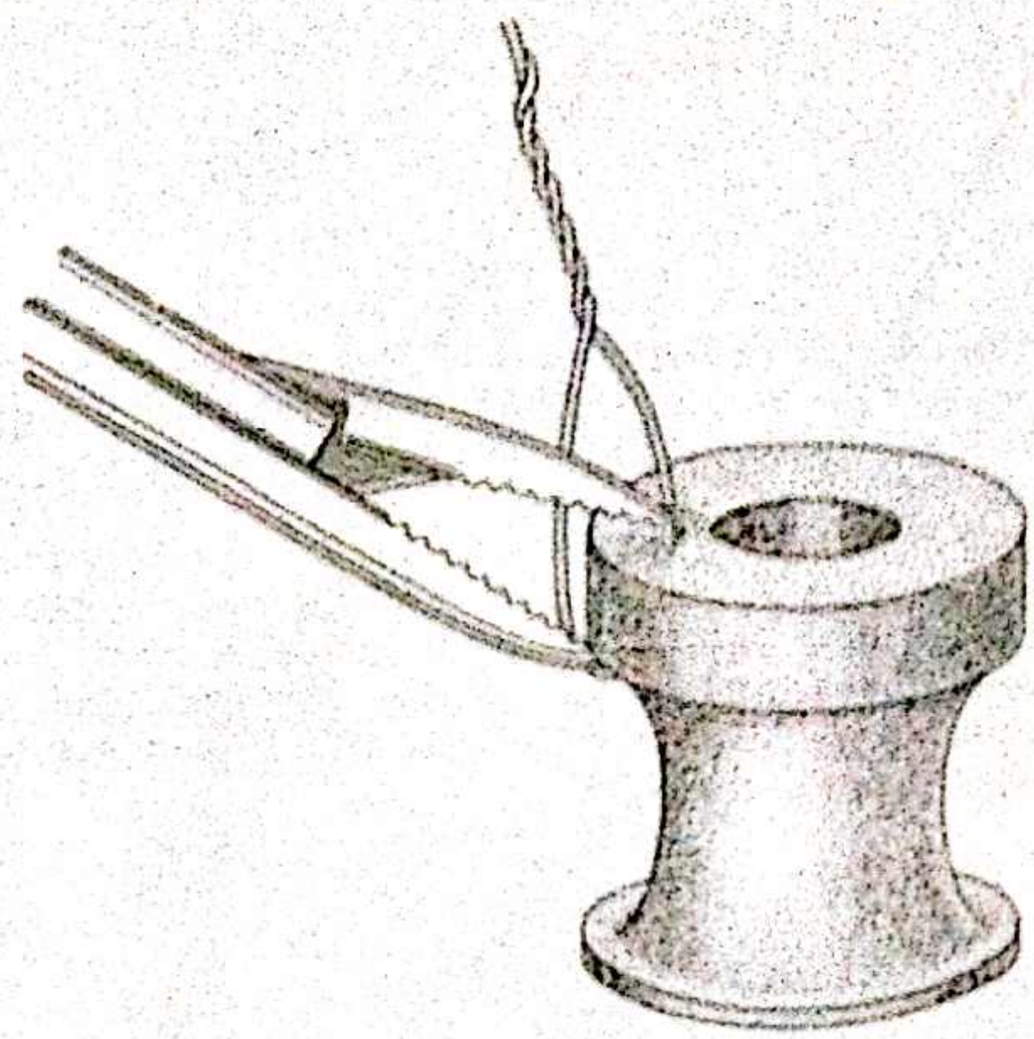
Short-term ventilation

8

One of the older designs and still one of the most popular is the Shepard VT, available in Teflon or silicone with either an attached stainless steel wire or an integral tail of the same material, either of which can be cut as short as required.

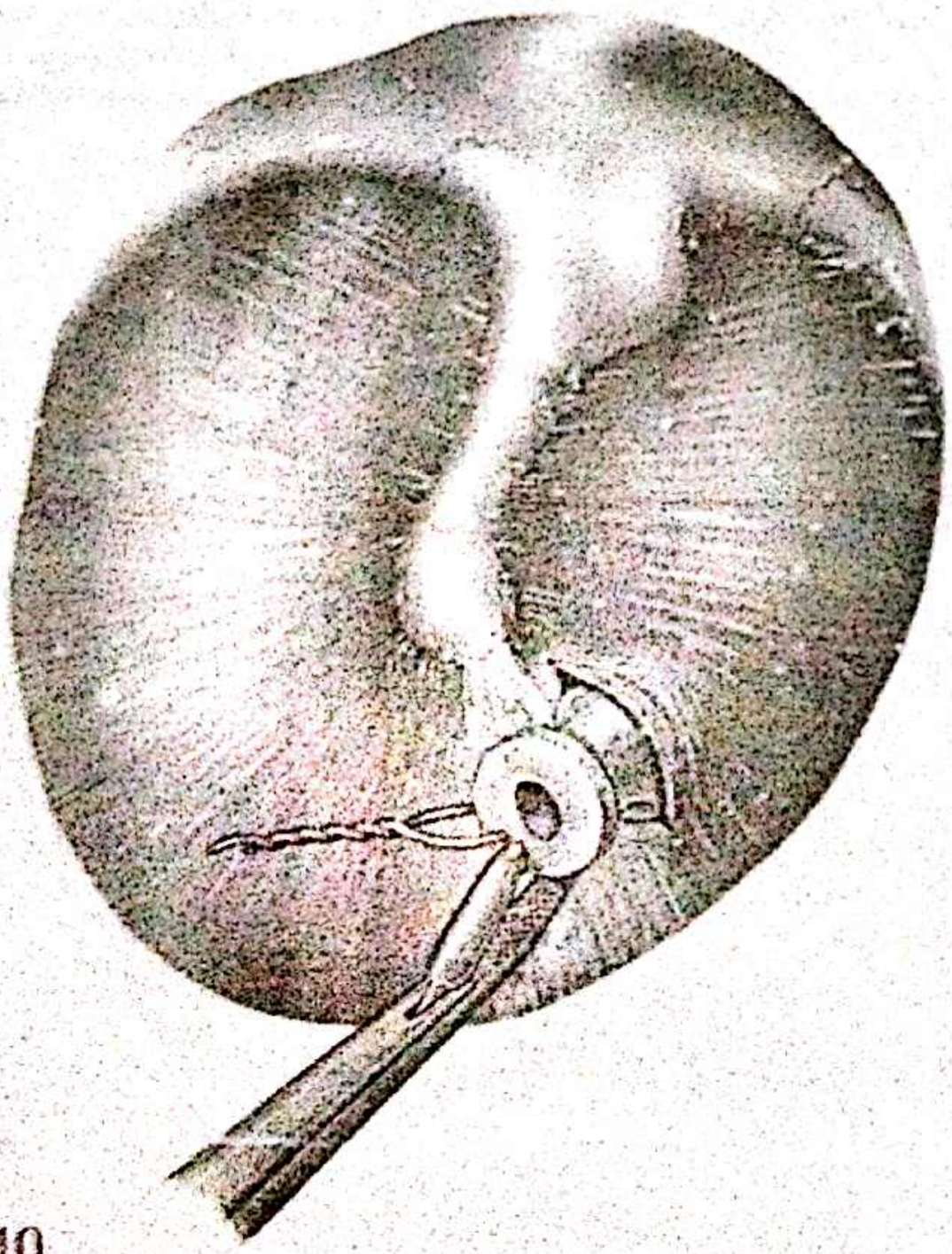
9a & b

After performing the myringotomy, the VT is grasped with very fine crocodile forceps as shown (a). (The 'wrong' grasp (*b*) makes the next manoeuvre more difficult.)



9a

9b



10

When using an anteroinferior incision, the shaft of the forceps is held posteroinferiorly, and one edge of the inner flange is gently pushed under the superior margin of the incision.

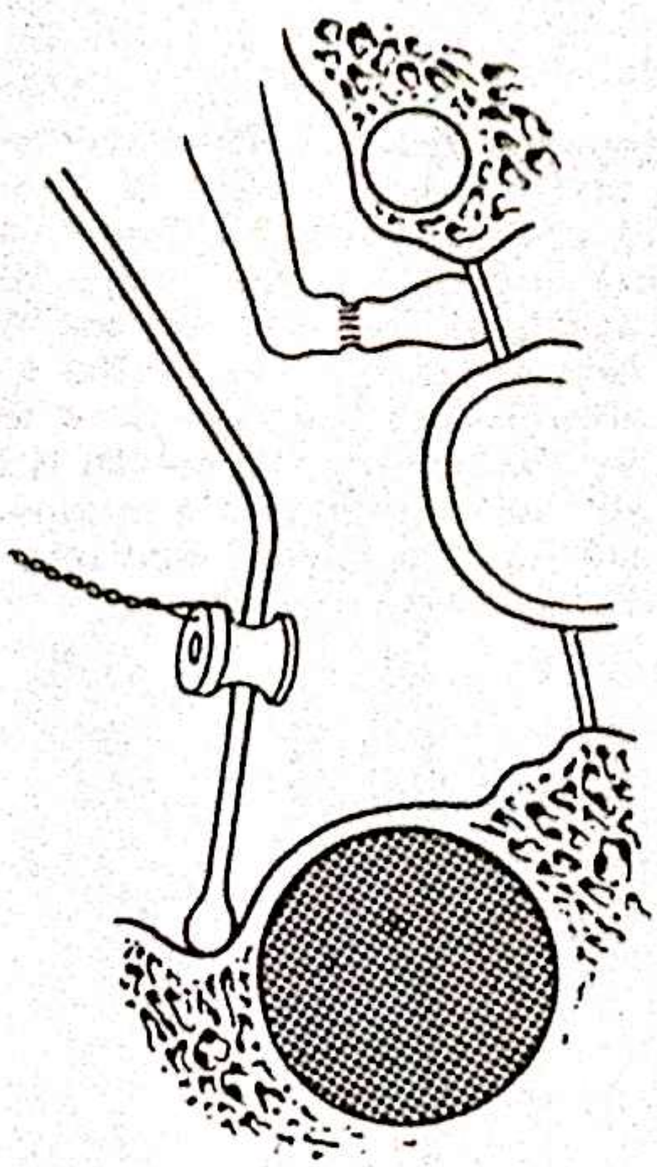
10

11

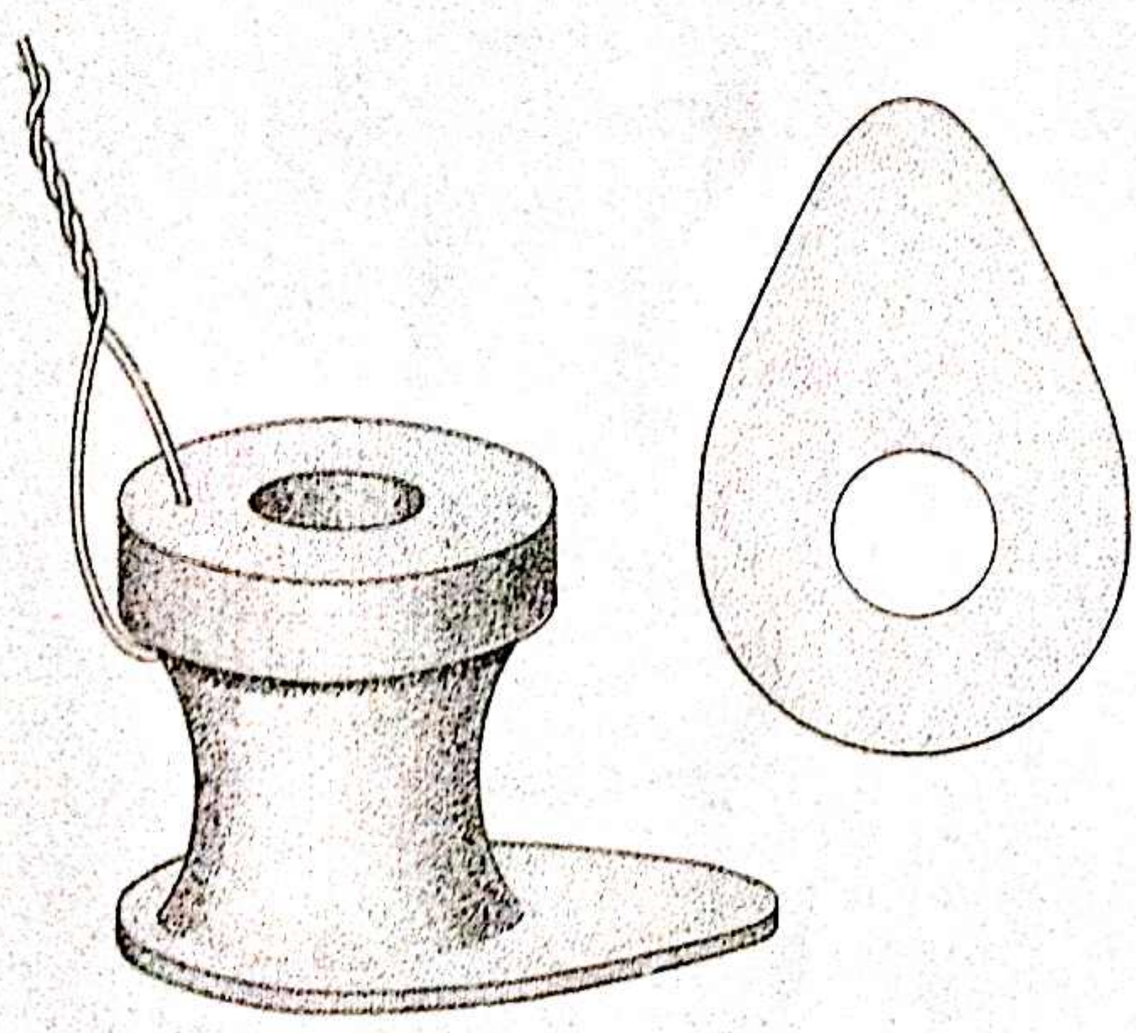
The whole inner flange of the tube is then carefully slid through the incision so that the 'waist' is gripped by the edges of the incision.

Alternatively, the VT may be placed with the inner flange alongside the incision with crocodile forceps. Then the flange is gently pushed under the superior margin of the incision using a right-angled pick or curved needle. Finally gentle pressure is applied to the inferiorly placed part of the flange, when it too will pass through the incision and the tube snaps into position.

Gibb's study[1] has shown that the Shepard tube and the similar Donaldson tube tend to be extruded more rapidly than other designs – 45 per cent within 6 months. Their use is indicated when the need for medium- or long-term ventilation is not expected – for example for first attacks of SOM when VT insertion is combined with adenoidectomy. They are easy to insert and so useful if the external canal is narrow.



11



12

Medium-term ventilation

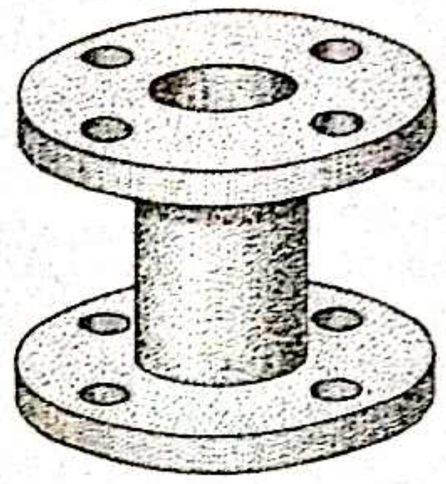
If ventilation for a year or two is considered desirable, for instance in patients with recurrent SOM, marked retraction pockets or ciliary dysfunction, one of the following tubes may be selected. Some surgeons, however, use medium-term tubes routinely, on the grounds that it is difficult to predict for how long ventilation will be required.

12

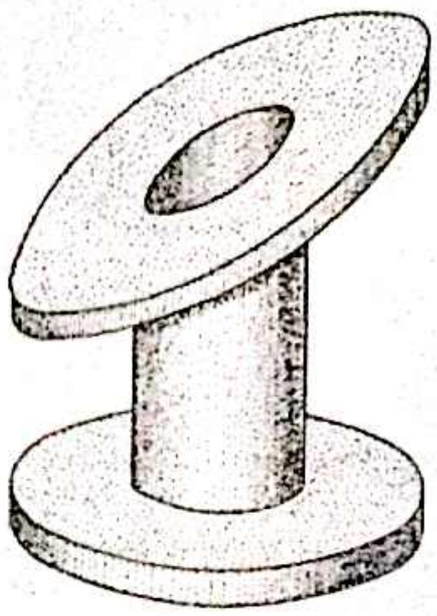
The Shah grommet is made of Teflon and has an elongated inner flange as shown. It is easy to insert, as the narrow tip of the almost triangular flange slips readily under the upper margin of the incision. The long flange helps to prevent extrusion, which may be even further delayed if the tube is rotated so that the tip of the long flange points towards the malleus handle.

13

The Reuter bobbin is made of Teflon or stainless steel, and is available with a standard lumen of 1.1 mm internal diameter and a larger lumen of 1.25 mm, which is less liable to block, especially as the tube is also of short length. The slightly wider thin flanges and 90° flange-to-tube angle help to resist extrusion. The holes in the flanges may allow tissue to grow into them, which would help to anchor the bobbin. The bobbin is inserted by grasping it with very fine crocodile forceps between a flange hole and the outer edge of the flange. It is not as easy to insert as the short-term tubes.



13



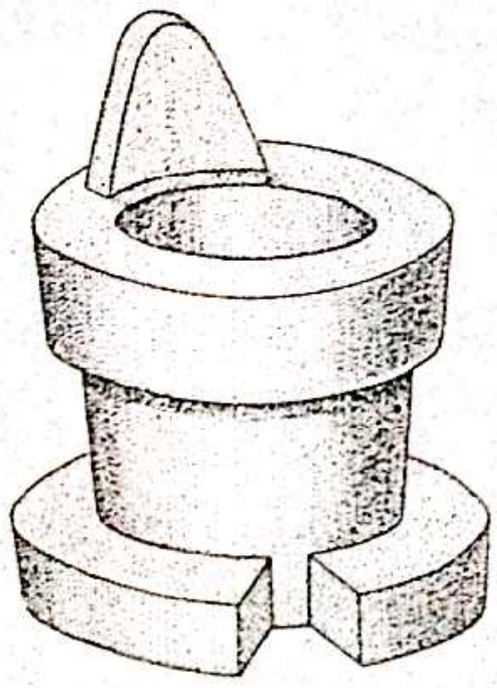
14

14

The Armstrong bevelled tube is available in Teflon or silicone. The angle of the inner flange to the shank is designed to facilitate sliding it into place through a smaller incision.

15

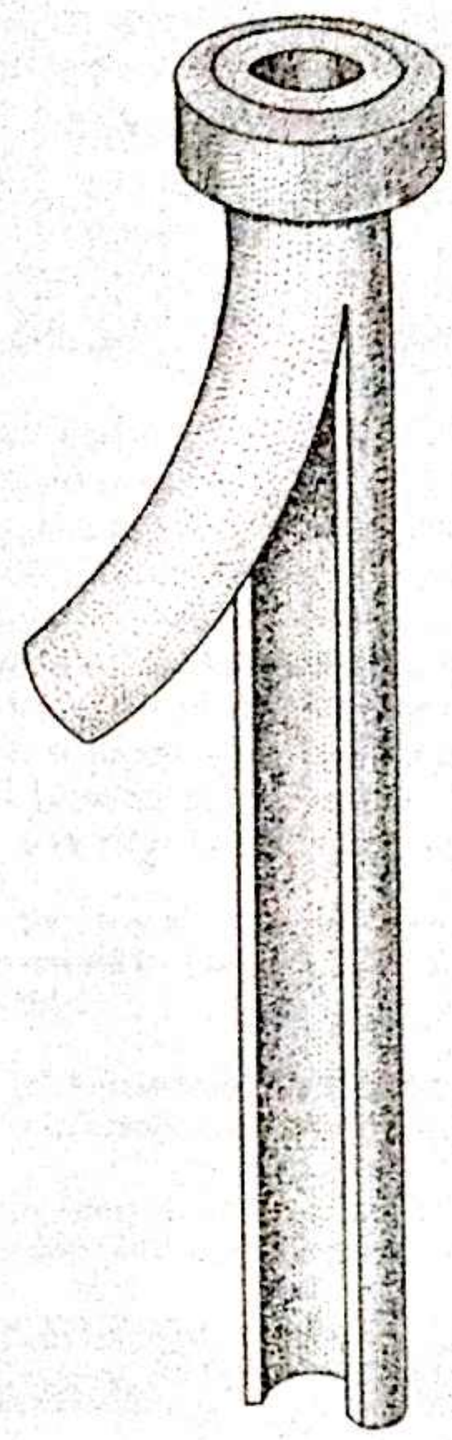
The Paparella type 1 tube is a soft silicone tube with a notched inner flange. It is introduced by inserting one corner of the notch through the incision and then rotating the tube with a screwing movement until the whole flange has passed through the incision. This manoeuvre and the soft material enables it to be passed through a smaller incision.



15

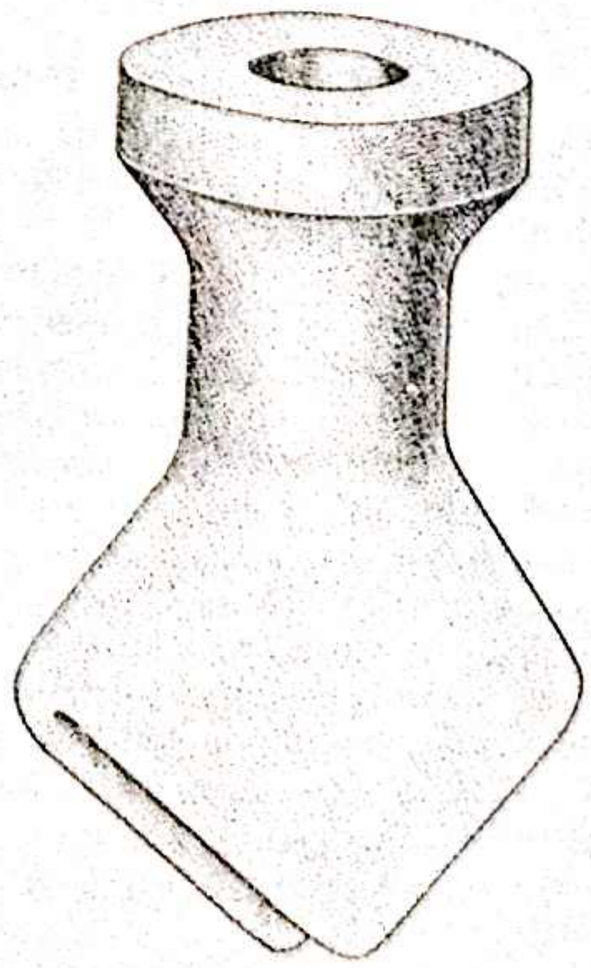
16

The Feuerstein split tube (and the similar J.S. Knight split tube which has an elongated flange) diminishes the liability to blockage by reducing the length of the lumen.



16

17

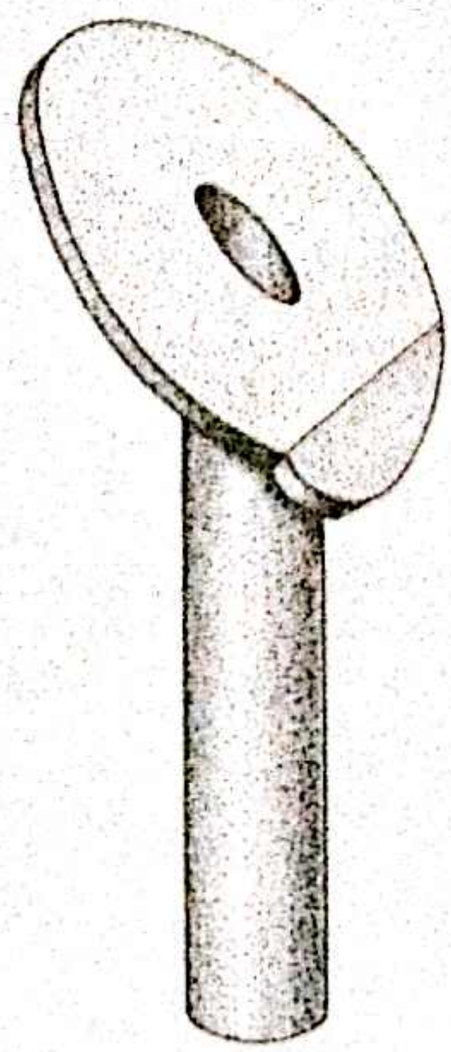


17

The Lindeman-Silverstein arrow tube is available in Teflon and silicone. The widely flared inner flange increases anchorage and is slotted so that there is wide access to the lumen even if the tip touches the promontory. It is inserted with the flat surface of the arrow parallel to the incision.

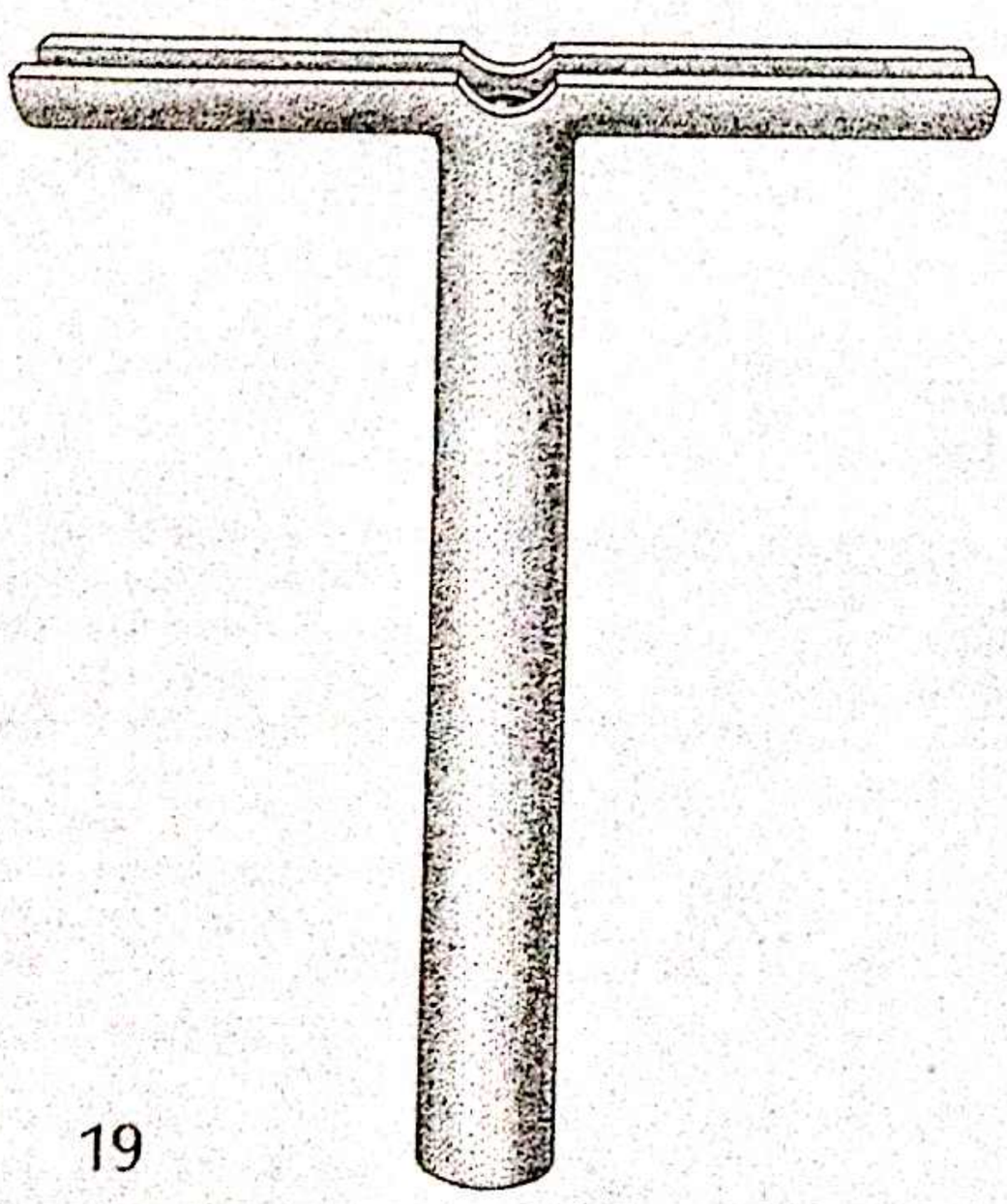
Long-term ventilation

This may be planned in very refractory cases of SOM in which there is recurrence of middle ear fluid and hearing impairment as soon as a VT is extruded or blocked. Tubes designed for this purpose depend on large flanges as an anti-extrusion device, and some have a wider lumen to diminish the tendency to blockage.



18

The Per-Lee tube[5], made of silicone, has been found to be very effective in resisting extrusion. The very wide flange, though bulky, is soft but may require a slightly larger myringotomy. Part of the flange should lie deep to the malleus. The flange and tube length can be trimmed as appropriate.



19

The Goode T-tube[6] is made of silicone and its lumen opens into a half tube set at right angles to form a T. The method of insertion is as follows.

A curved myringotomy incision is made in the inferior part of the tympanic membrane, parallel to and 2 mm above the annulus. The two half tubes are then folded towards each other to form a cylinder and held in this position by grasping them with fine crocodile forceps at their junction with the tube. Keeping them together in this way the two half tubes are passed through the myringotomy. The two half tubes should now separate and lie parallel to the floor of the middle ear. Alternatively, one half tube can be passed through the myringotomy first with crocodile forceps, and the second half tube then folded into the middle ear with a pick[6]. An advantage of this tube is said to be that it is easy to remove, despite the large T-flanges, without a second myringotomy – the two half tubes collapse readily.

Paparella type 2 and 3 tubes are similar to type 1 and also of soft silicone. They have larger lumens and wider flanges in order to resist blockage and extrusion.

Postoperative care

Secretory otitis media

Patients who have had a general anaesthetic can normally leave hospital as soon as they have recovered from its effect. Further management consists of follow-up audiometry and periodic review until the VT is extruded. It is rarely if ever necessary to remove tubes designed for short- or medium-term ventilation. Whether and when a long-term tube is removed depends on the individual factors of each case. Patients are advised to avoid water entering the ears as this may cause middle ear infection. Thus, swimming is best avoided. However, if this is a great deprivation the patient can be given a trial swim with ear plugs or cotton wool smeared with vaseline and a tight bathing cap. If no infection results swimming can be allowed.

Acute suppurative otitis media

Antibiotic treatment is continued but may have to be changed once the results of the swab taken at operation are known. Aural toilet by dry mopping of the canal with cotton wool is carried out as often as discharge re-appears in the canal.

Complications

The myringotome can damage the incus, stapes, incudostapedial joint, facial nerve or chorda tympani if the incision is made posteriorly and too high (see *Illustration 7*); hence the vital importance of very good magnification and illumination. A rare complication is damage to the jugular bulb, which is occasionally situated in the lower mesotympanum with a very thin wall; this anatomical variant must be borne in mind as it is very vulnerable to the myringotome.

Acute suppurative otitis media occasionally develops immediately after grommet insertion or if a patient swims with a grommet in. It usually responds to antibiotics, but rarely the discharge persists until the grommet is removed.

Grommets can cause damage to the ossicular chain if placed through the posterior half of the drumhead..

Myringotomy and grommet insertion leads to considerable scarring and hyaline degeneration in the drumhead in a high proportion of cases. Fortunately these changes are only rarely associated with significant hearing loss.

References

1. Politzer, A. Textbook of diseases of the ear, pp. 375–377. Translated and edited by Cassells, J. P. London: Baillière, Tindall & Cox, 1883

2. Armstrong, B. W. A new treatment for chronic secretory otitis media. Archives of Otolaryngology 1954; 59: 653–654

3. Gibb, A. G. Long-term assessment of ventilation tubes. Journal of Laryngology and Otology 1980; 94: 39–51

4. Paradise, J. L. On tympanostomy tubes: rationale, results, reservations and recommendations. Paediatrics 1977; 60: 86–90

5. Per-Lee, J. H. Experiences with a 'permanent' wide flange middle ear ventilation tube. Laryngoscope 1969; 79: 581–591

6. Goode, R. L. T-tube for middle ear ventilation. Archives of Otolaryngology 1973; 97: 402–403

Illustrations by Gillian Lee

Stapedectomy

John C. Ballantyne CBE, FRCS, HonFRCSI, DLO
Consultant Ear, Nose and Throat Surgeon, Royal Free Hospital and King Edward VII Hospital for Officers, London, UK

Preoperative

Indications

Stapedectomy is indicated in cases of conductive or 'mixed' deafness due to otosclerosis in which there is a good bone–air gap. Even in very advanced cases stapedectomy may enable the patient to obtain a satisfactory response to a hearing aid where previously this was not possible. The bone–air gap can be closed in over 90 per cent of suitable cases.

The operation should be performed in the worse hearing ear.

Contraindications

Stapedectomy should never be performed in the only hearing ear because of the ever-present risk, however slight, of a 'dead ear' (see 'Complications', p.46); it should also be avoided in children, who are much more liable than adults to develop postoperative sensorineural hearing loss, and in the presence of an acute upper respiratory tract infection (either in the patient or in the surgeon) or otitis externa. For patients in very poor general condition a hearing aid is to be preferred.

Preparation of the ear

Wax should be removed from the meatus by gentle suction, on the operating table and after the induction of anaesthesia when a general anaesthetic is used. The skin is prepared by cleansing it with cotton wool dipped in an aqueous solution of cetrimide. Solutions of chlorhexidine (Hibitane) in spirit should not be used for this purpose as there is some evidence that they may be ototoxic.

Anaesthesia

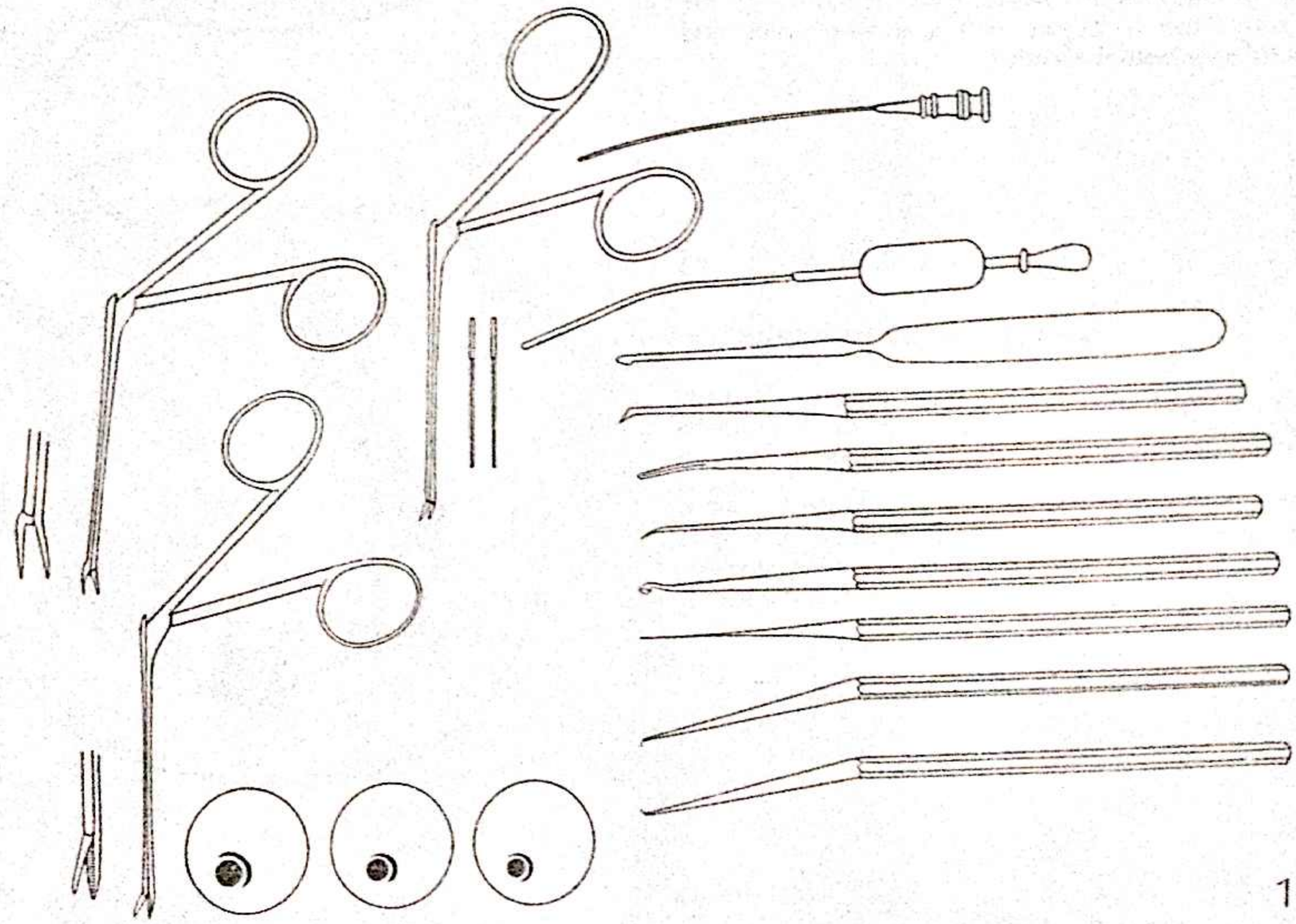
In many countries the operation is performed under sedation with a topical anaesthetic. The analgesic solution (e.g. 1 or 2 per cent lignocaine with 1:200 000 adrenaline) is injected through the skin at the level of the outer border of the posterosuperior bony meatus, just medial to the suprameatal spine; a sufficient quantity is introduced to raise the skin and periosteum of the posterior meatal wall from the underlying bone, down to the tympanic annulus.

However, general anaesthesia with hypotension is to be preferred. Premedication with pethidine 75 mg and promethazine 25 mg is given intramuscularly 1 hour before surgery. General anaesthesia is induced with thiopentone (Pentothal) and followed by curare 30 mg, with inhalation of nitrous oxide, oxygen and halothane; controlled ventilation is used throughout. To produce effective hypotension the table is tilted feet downwards for 20–25°; the hypotensive drug may be practolol (Eraldin) 5–10 mg stat. according to pulse rate; pentolinium tartrate (Ansolysen) 10–20 mg; or sodium nitroprusside 0.01 per cent solution by intravenous drip. The amount of drug is adjusted so as to maintain a systolic pressure of 60 mmHg.

1

Instrumentation

Apart from the binocular operating microscope, the essential instruments for stapedectomy are: a selection of aural specula (*bottom left*); curved suckers of the Rosen and Zöllner types (*top right*), with extra-fine adjustments for the latter (*left* of Zöllner sucker); a range of fine hand instruments, mainly black and of hardened steel (*right*). From *top to bottom* these are a first-incision knife (Lempert type); a semi-sharp knife-elevator (Cawthorne type); a curved blunt elevator (Rosen); a curved needle (Rosen); a bone scoop (Rosen); a straight needle; and two angled needles, one with the point forwards and one with the point backwards. Fine crocodile forceps with serrated jaws (*bottom left*); crimping forceps of McGee type (*top left*); and microscissors (*top centre*) are also essential.



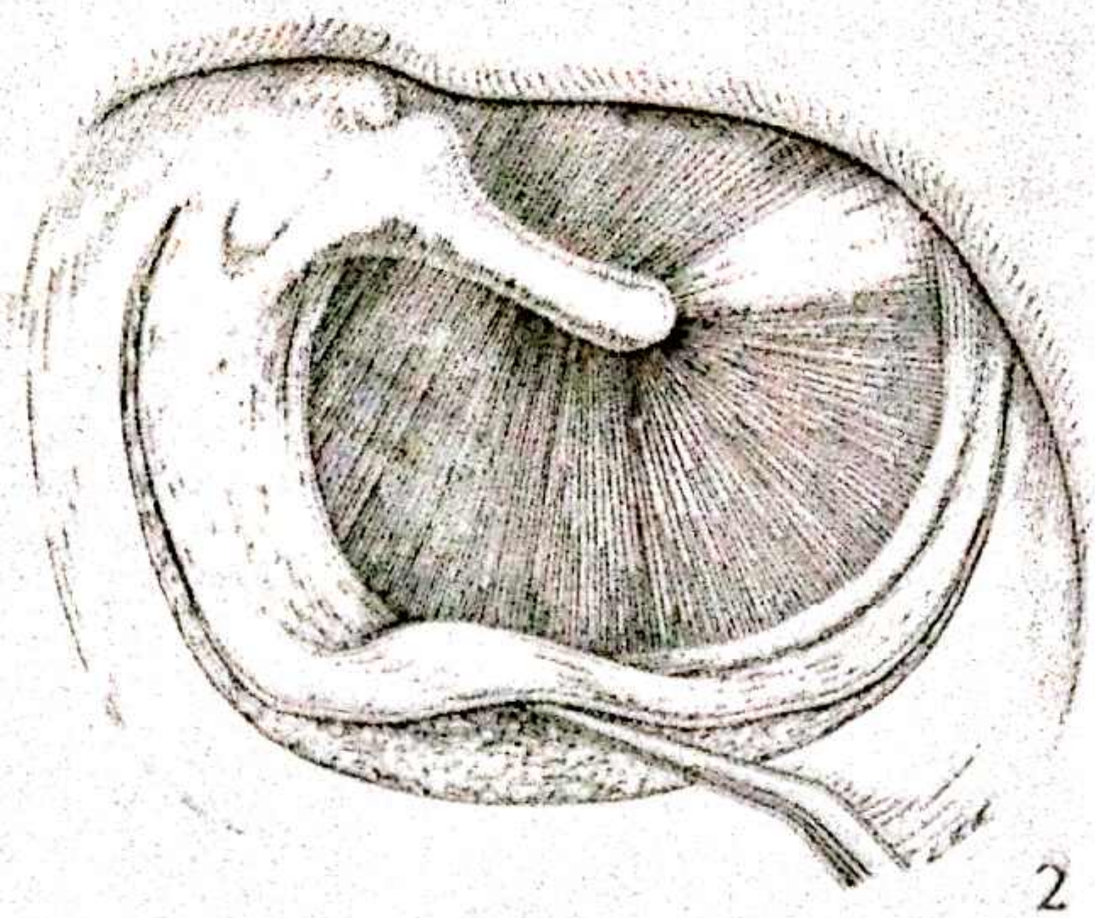
1

The operation

2

The approach

Under ×6 magnification the middle ear is entered through a posterior tympanotomy. An incision is made, with a first incision knife, from the 6 o'clock position directly outwards into the meatus, to the level of the isthmus. A second incision starting from the 12 o'clock position, immediately above the short process of the malleus, curves outwards and then downwards to meet the outer end of the first incision. Elevation of the skin from the underlying bone is begun with a knife-elevator and continued with a blunt elevator.

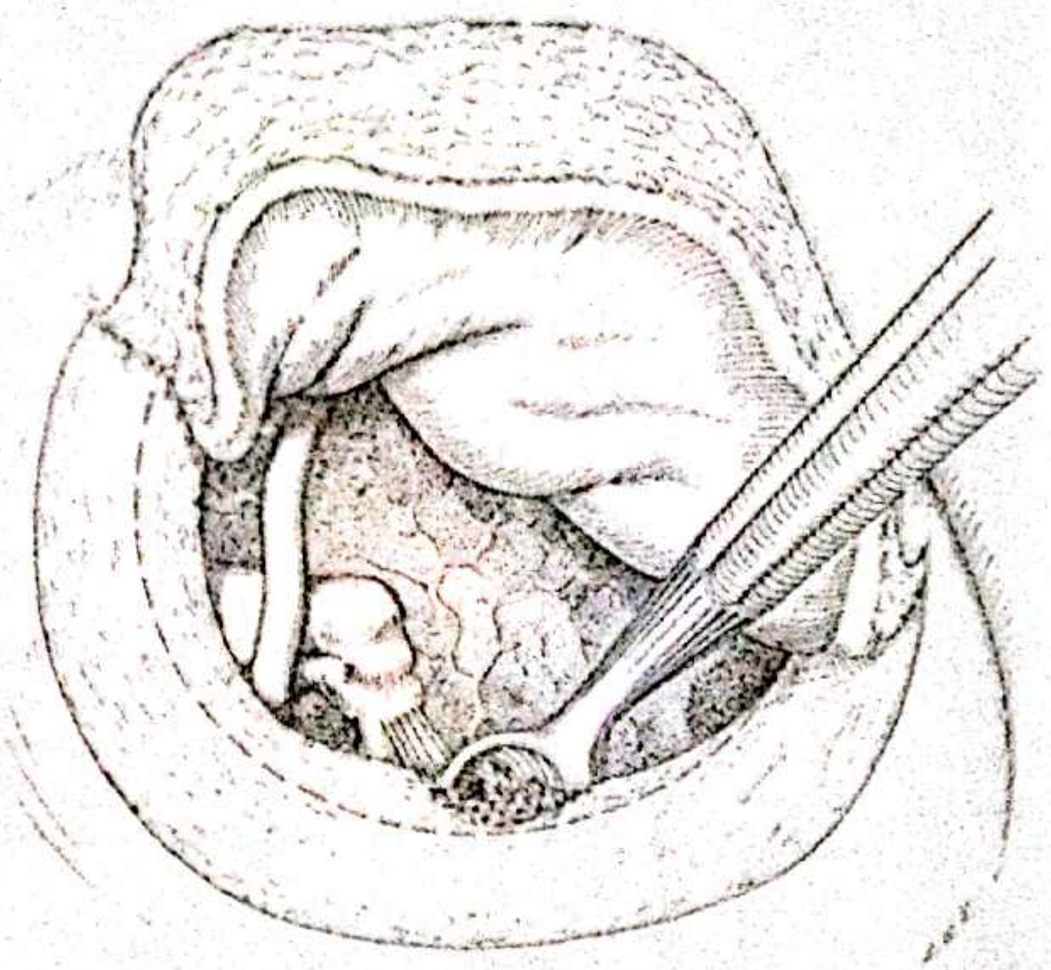


2

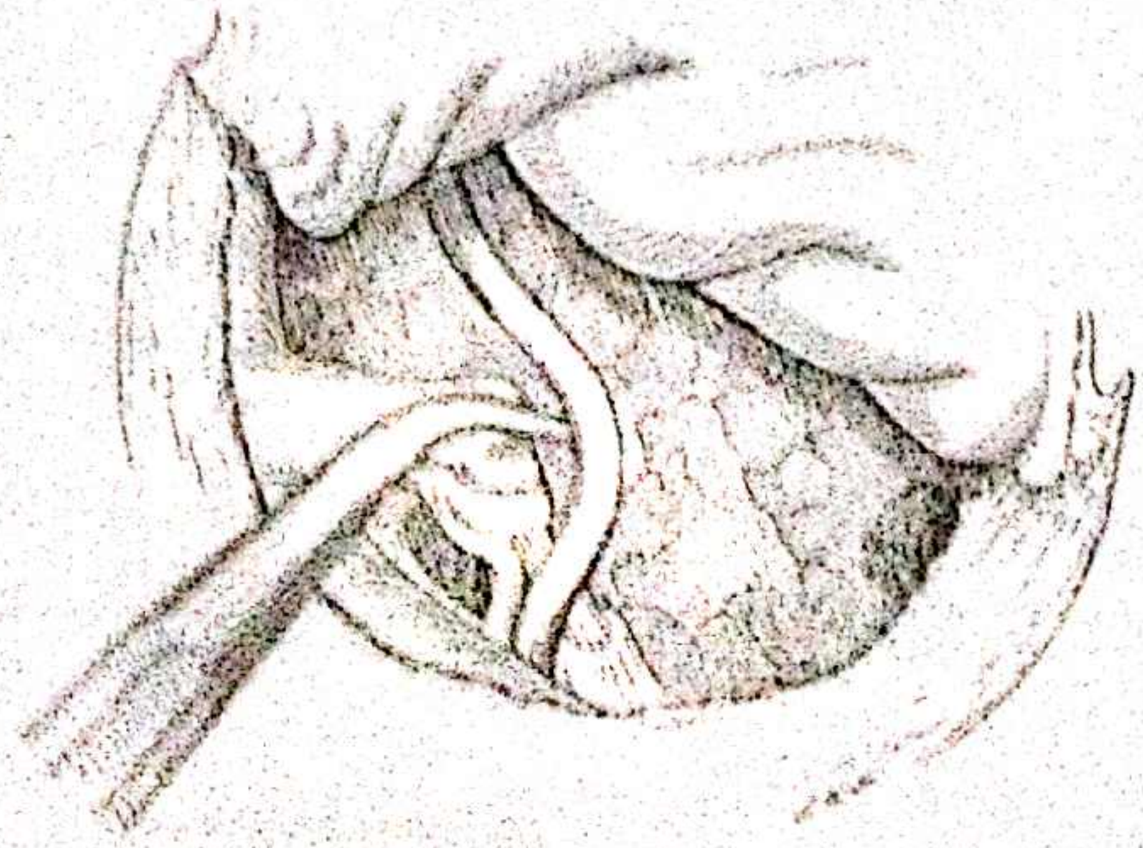
3

Elevation of tympanomeatal flap

The fibrocartilaginous tympanic annulus is reflected out of the bony sulcus, beginning at the posterosuperior 'angle'. This exposes the chorda tympani nerve, running forwards lateral to the lower end of the long process of the incus.



3



4

Reflection of the chorda tympani and removal of meatal bone

The nerve can usually be reflected downwards with a curved Rosen needle, beyond the tip of the incus, without undue stretching; if this is not possible it is better to cut the nerve cleanly with crocodile microscissors.

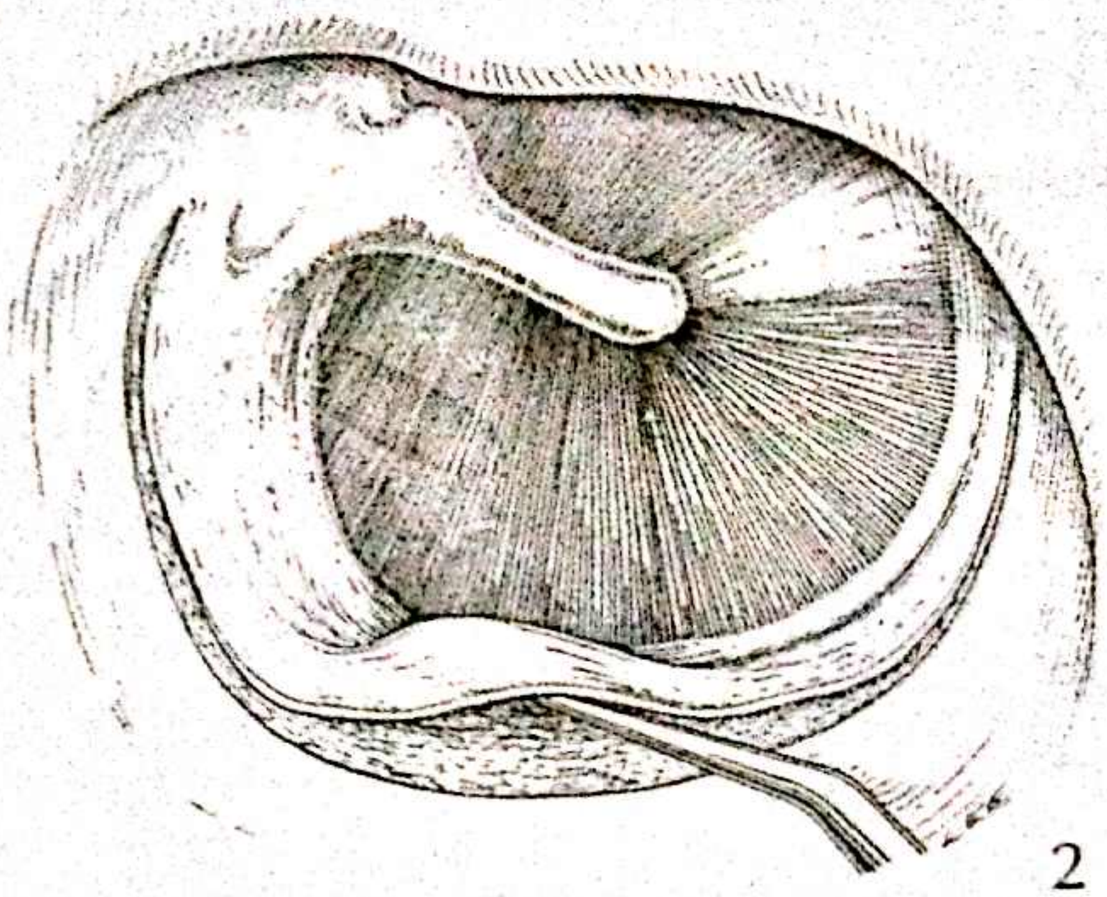
The area of bone indicated by the interrupted line in *Illustration 3* is removed from within outwards with a scoop, and sufficient bone should be removed to expose the pyramid and stapedius tendon, the stapedial footplate and part of the horizontal portion of the bony Fallopian canal.

The operation

2

The approach

Under ×6 magnification the middle ear is entered through a permeatal tympanotomy. An incision is made, with a first-incision knife, from the 6 o'clock position directly outwards into the meatus, to the level of the isthmus. A second incision starting from the 12 o'clock position, immediately above the short process of the malleus, curves outwards and then downwards to meet the outer end of the first incision. Elevation of the skin from the underlying bone is begun with a knife-elevator and continued with a blunt elevator.

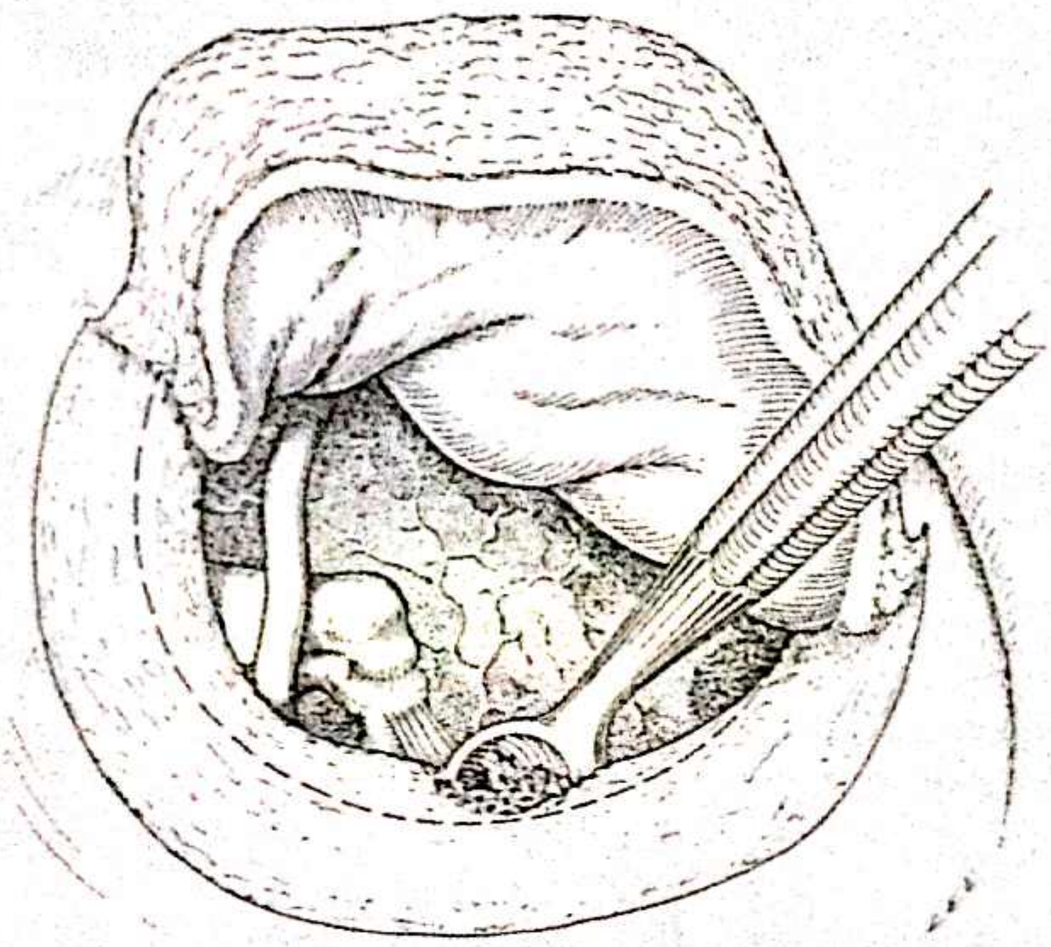


2

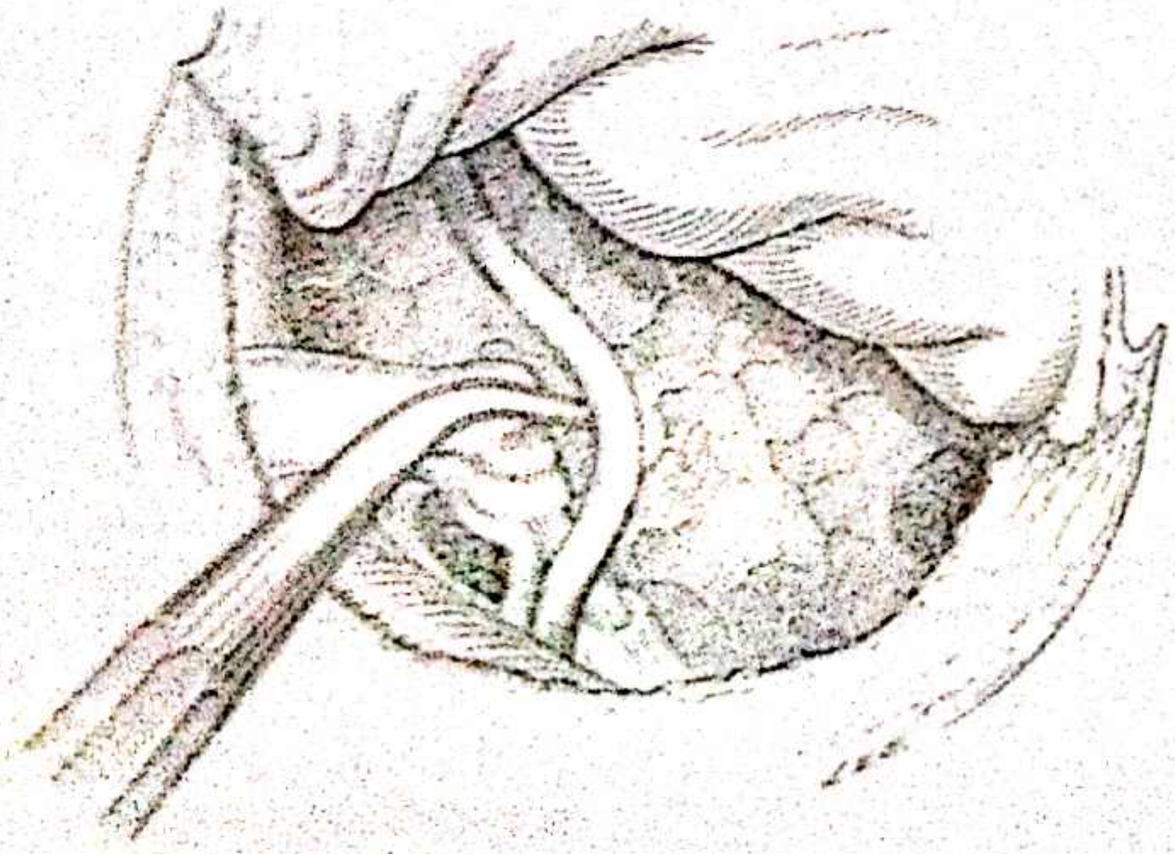
3

Elevation of tympanomeatal flap

The fibrocartilaginous tympanic annulus is reflected out of the bony sulcus, beginning at the posterosuperior 'angle'. This exposes the chorda tympani nerve, running forwards lateral to the lower end of the long process of the incus.



3



4

4

Reflection of the chorda tympani and removal of meatal bone

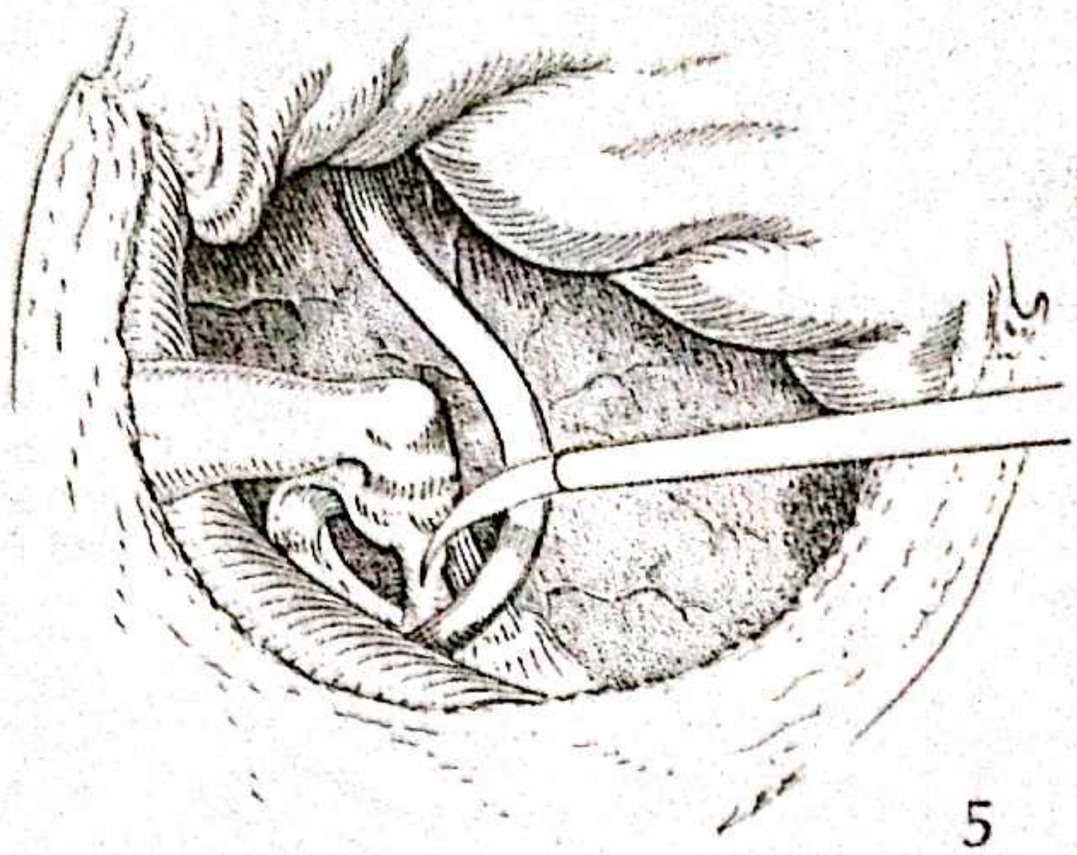
The nerve can usually be reflected downwards with a curved Rosen needle, beyond the tip of the incus, without undue stretching; if this is not possible it is better to cut the nerve cleanly with crocodile microscissors.

The area of bone indicated by the interrupted line in *Illustration 3* is removed from within outwards with a scoop, and sufficient bone should be removed to expose the pyramid and stapedius tendon, the stapedial footplate and part of the horizontal portion of the bony Fallopian canal.

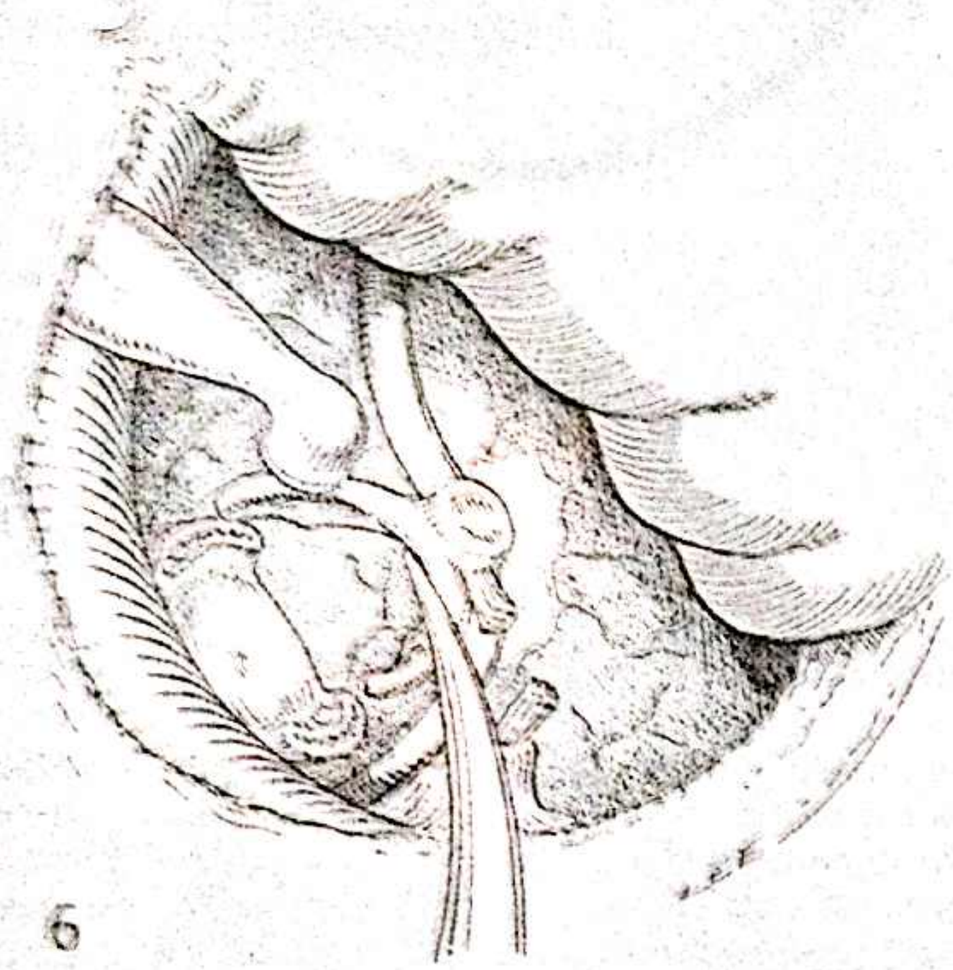
5

Section of the stapedius tendon

After confirming the mobility of the malleus and incus, and the immobility of the stapes, the stapedius tendon is cut with a curved sickle knife near its emergence from the pyramid.



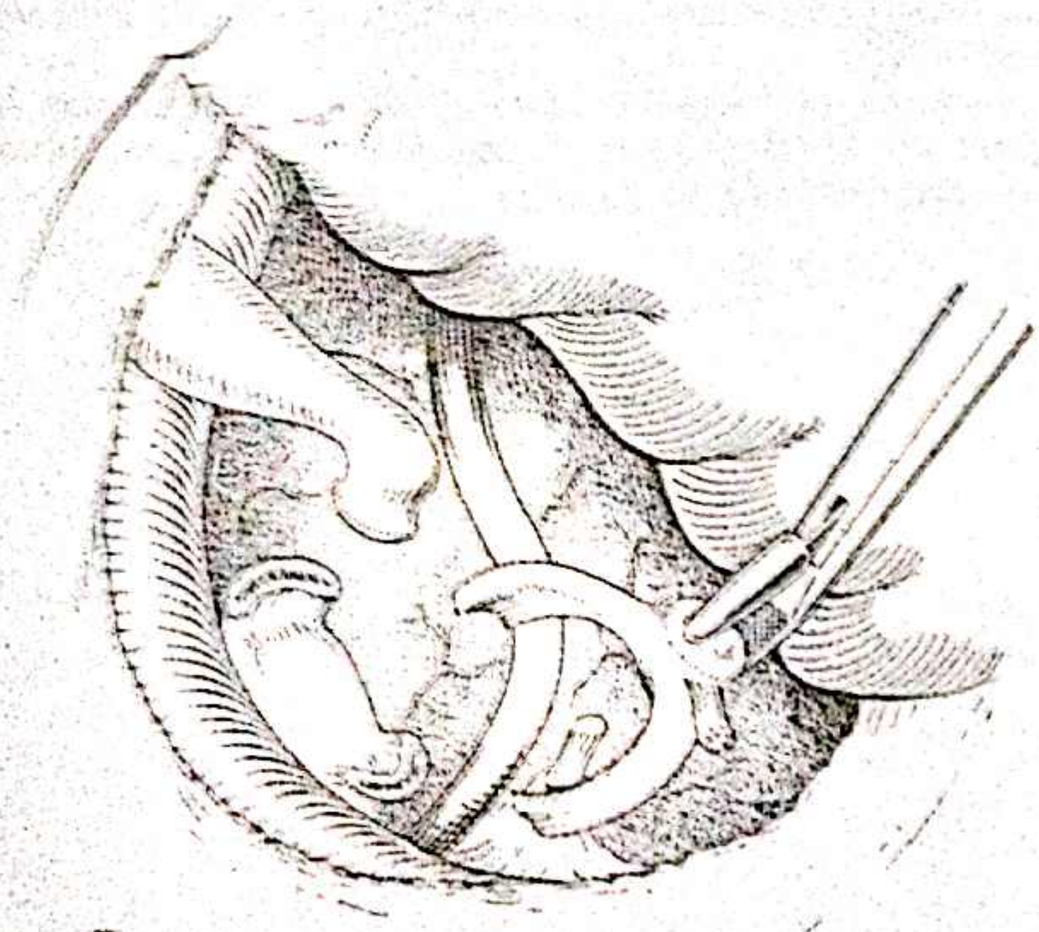
5



6

Fracture of the stapedial crura

Using ×10 magnification the crura are fractured near their attachment to the footplate by a sharp downward movement on the neck of the stapes with Rosen's curved needle.



7

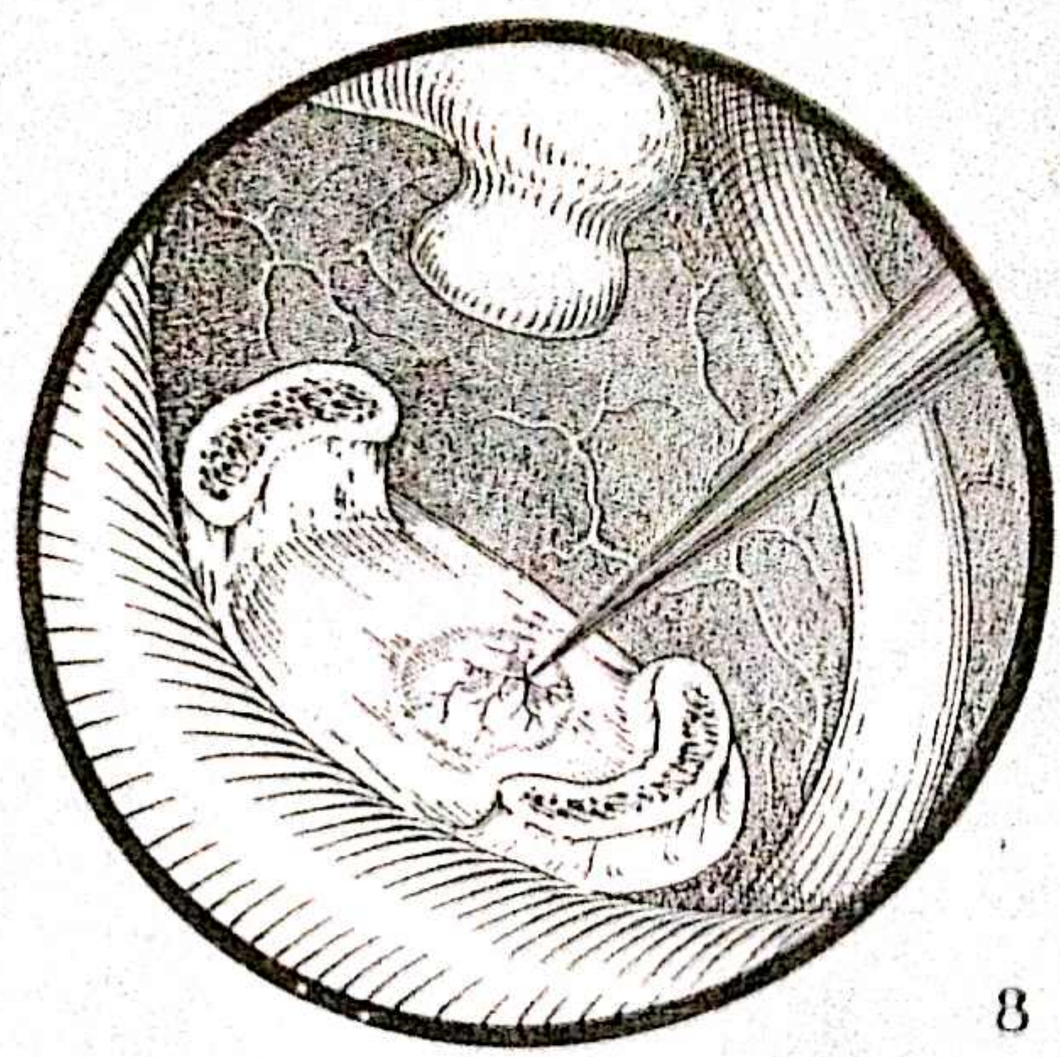
Removal of stapes superstructure

The head, neck and crura, together with the sectioned stapedius tendon, are removed with serrated crocodile forceps.

8

Penetration of the footplate

Work on the footplate is carried out under ×16 magnification. A relatively thin blue area can be penetrated by hand, with great care, by a twirling movement of a straight needle, which produces a 'cracked ice' effect. A posterior entry is preferred.



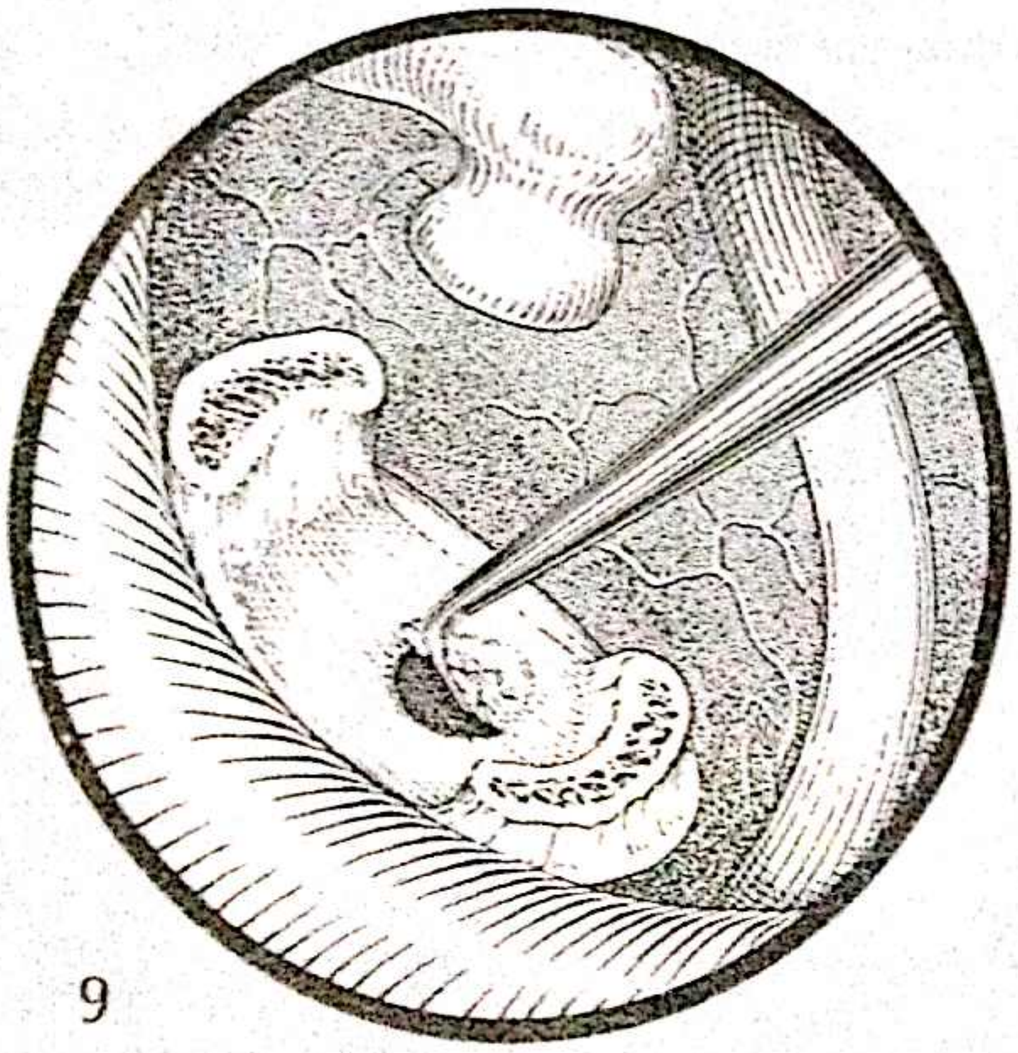
8

9

Removal of the footplate

Approximately one-third of the footplate is removed, either in one or in several pieces, by insinuating the tip of a fine curved hook just under the margin of the free bony fragments and delivering them outwards. No suction should be used through the oval window, and if a part (or the whole) of the footplate 'floats' in the tide of perilymph it is usually better to resist the temptation to recover and remove it.

(In cases of Menière's disease the labyrinth can be destroyed by this route, after removal of the whole stapedial footplate, by forceps and suction.)



9

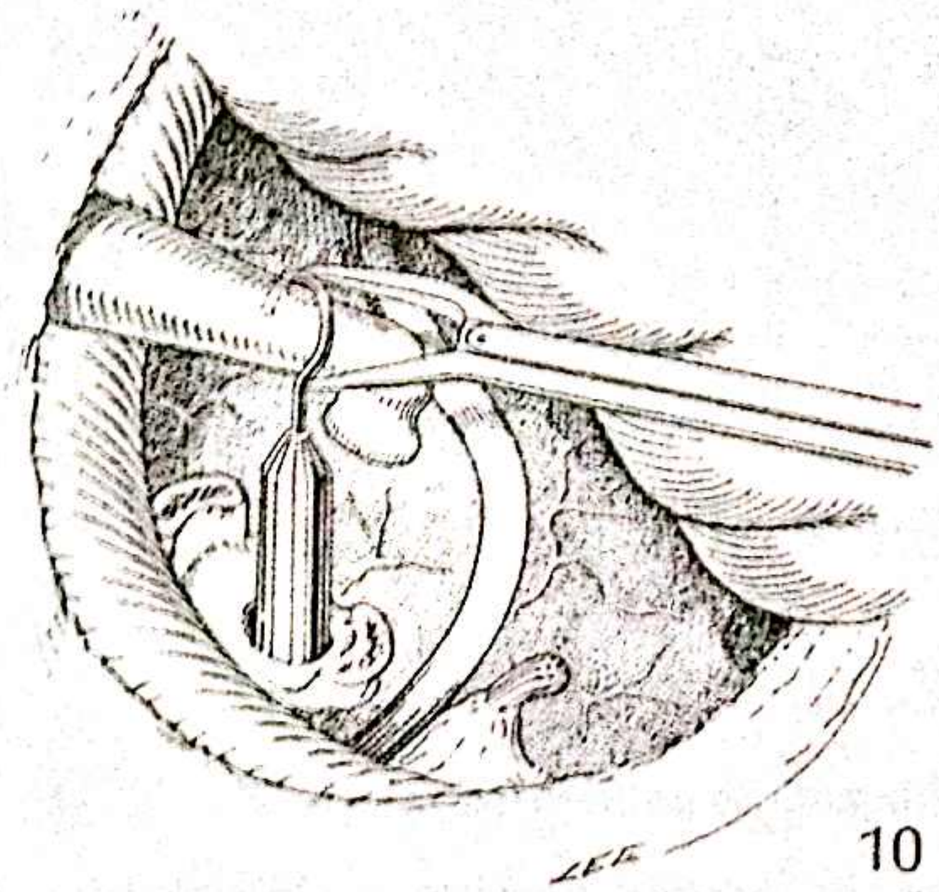
10

Insertion of the piston

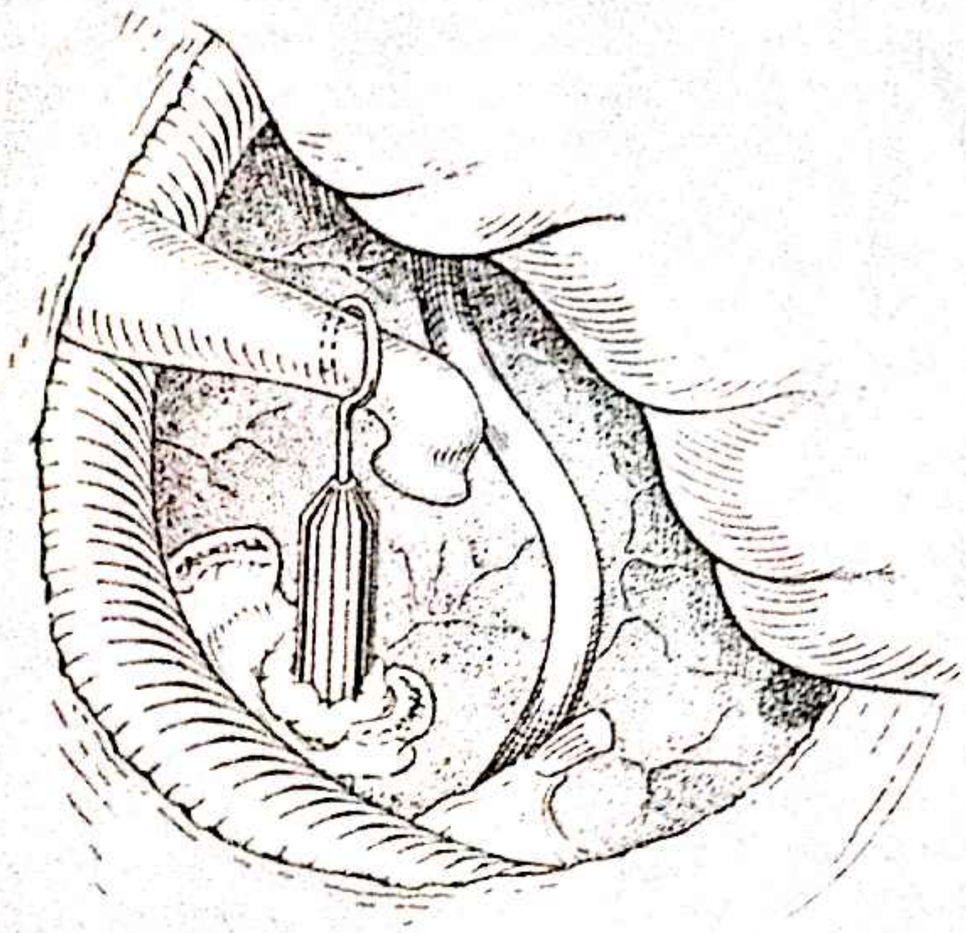
A McGee stainless steel piston, usually a standard one (0.8 mm diameter) of 4.0 mm length, is introduced with serrated crocodile forceps until the distal end of its body enters the opening made in the footplate. Care is taken to ensure that the open hook of the piston slips simultaneously over the long process of the incus without overriding it.

After any necessary adjustment of the position of the hook on the incus, it is closed with crimping forceps.

If the operation is being done under general anaesthesia nitrous oxide is discontinued at this point as it may diffuse into the closed tympanic cavity after the tympanomeatal flap has been replaced.



10



11

11

Sealing of the oval window

There is almost always a small gap, and sometimes a larger one, between the piston and the margin of the opening made in the footplate. This should be sealed off. Gelatin sponge is sometimes used, but there is evidence that some preparations of this material may be ototoxic; one or two small pieces of fat, readily obtained from the lobe of the ear, seat themselves very well around the piston.

Closure of the operative field

The tympanomeatal flap is replaced and three or four small pieces of gelatin sponge are placed over the line of the incision, the meatus being subsequently packed lightly with several larger pieces of sponge.

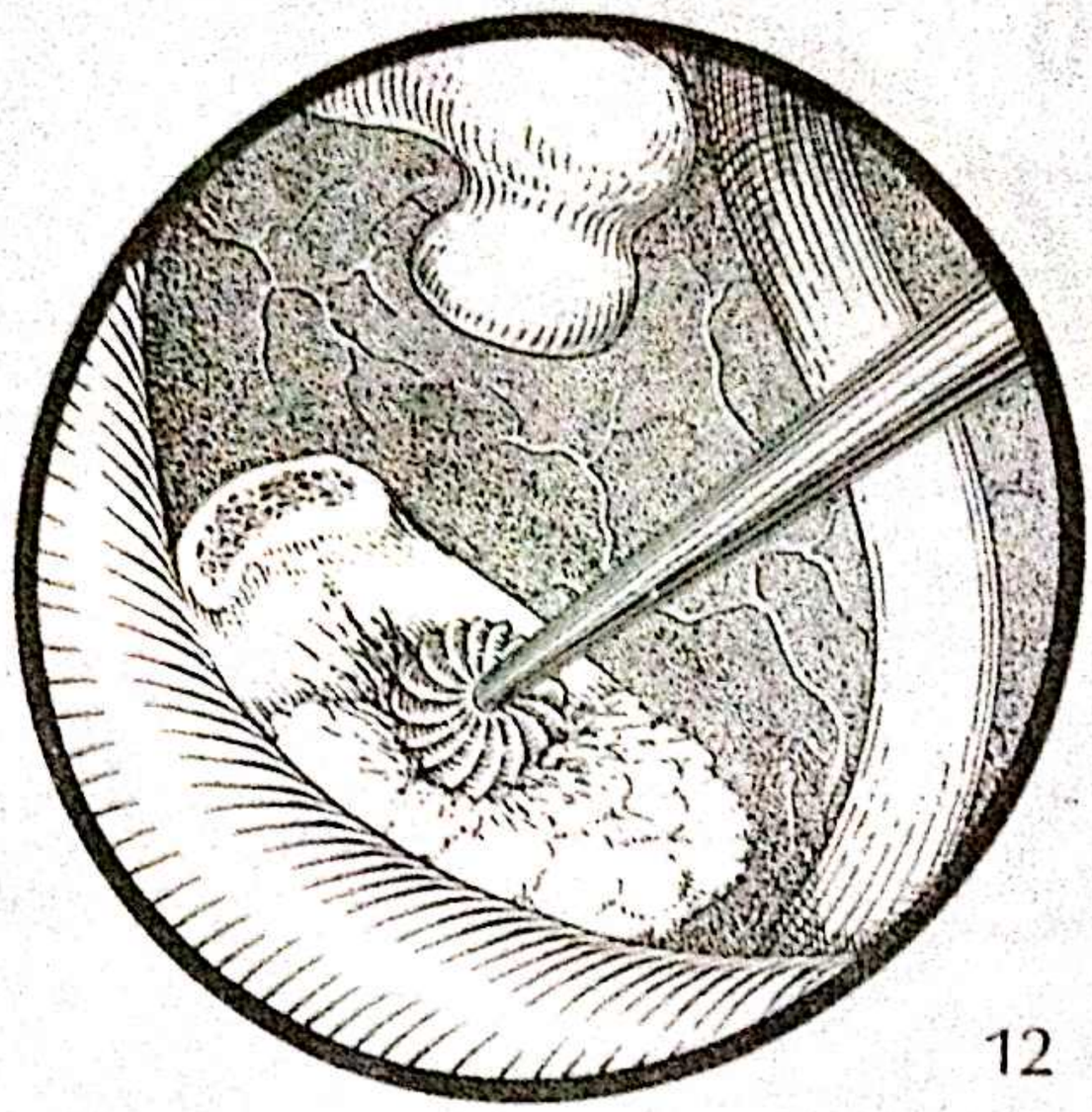
The operating table is restored to the horizontal position on completion of the surgery.

Modifications of technique

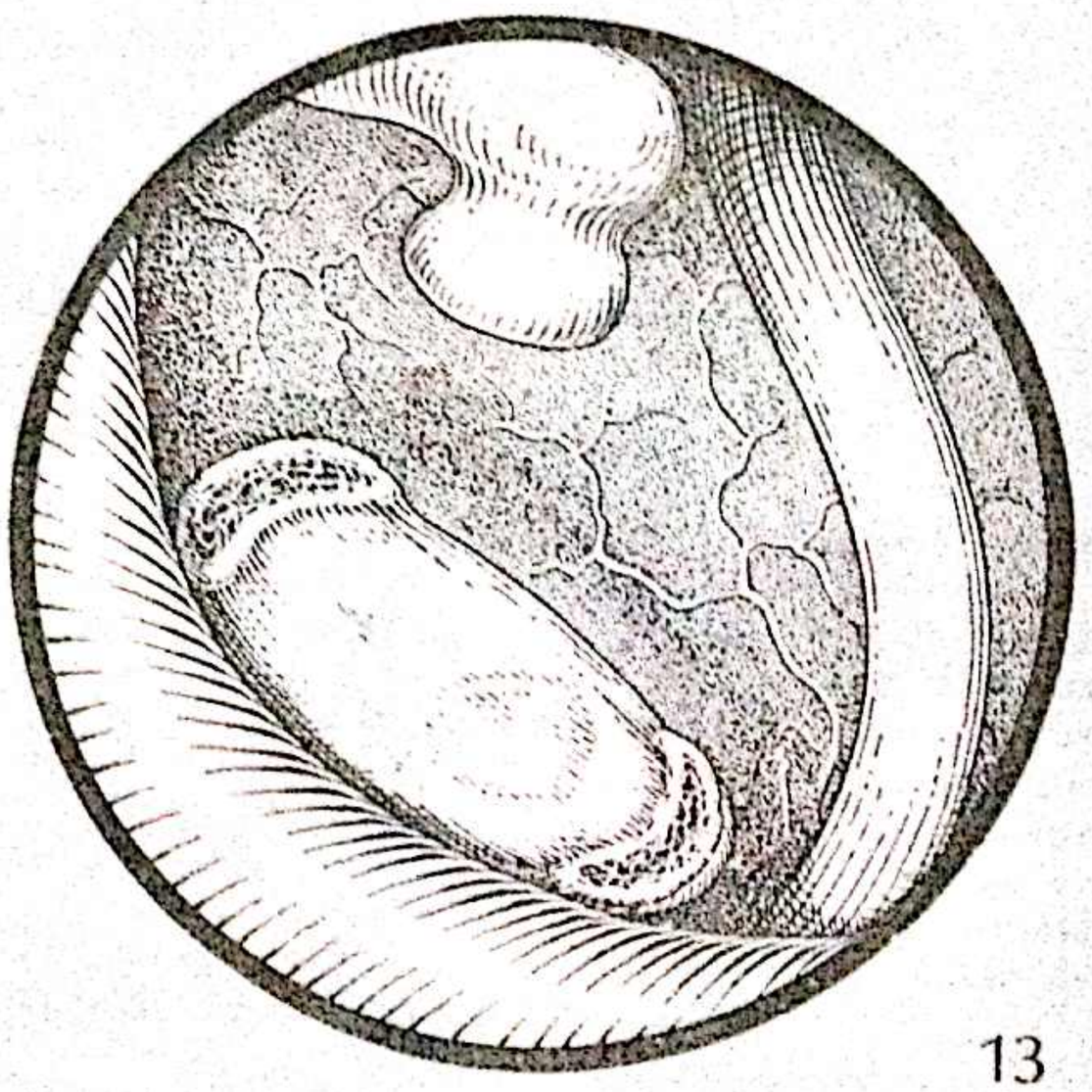
12 & 13

Drilling of the obliterated footplate

When the stapedial footplate is obliterated by dense overgrowth of otosclerotic bone this should be reduced with extreme care, by gentle anteroposterior strokes with a slowly rotating 1 mm cutting or diamond paste burr. Bone dust is removed periodically by suction-irrigation. When the footplate has been thinned to a blue condition it can be penetrated by hand and partially removed, as in the standard procedure.



12



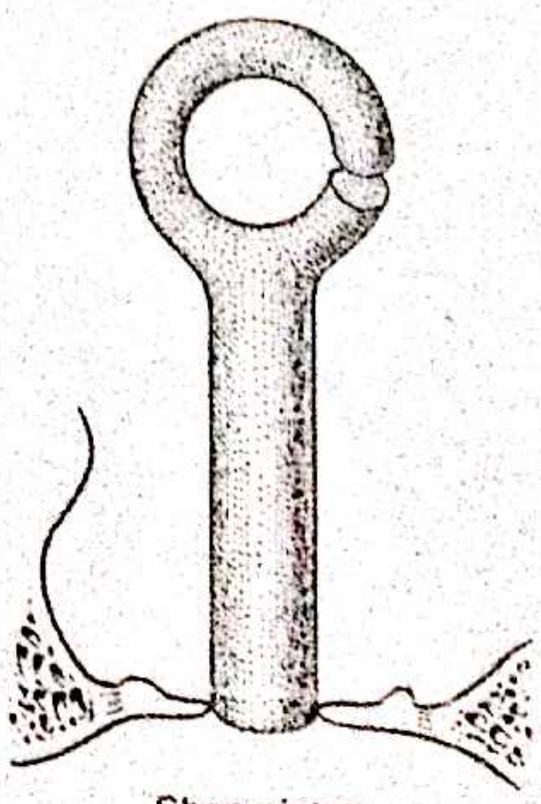
13

14

Alternative prostheses for partial stapedectomy

In addition to the standard McGee stainless steel piston, alternative sizes are available, the length varying in steps of 0.5 mm; the 'slimline' piston has a diameter of 0.6 mm.

Many surgeons prefer the Teflon (Shea) piston to the metal piston. The hook of this prosthesis is closed and must therefore be opened before being placed in the correct position around the long process of the incus. The final degree of closure is determined by the nature of the plastic material itself and the surgeon has no control over this once it has been inserted. In the majority of cases it is perfectly satisfactory, but occasionally, when the incus is thinner than usual, there may be excessive movement of the ring of the piston around the incus and thus reduced sound transmission; when the incus is thicker than average, it may cause delayed pressure necrosis of the tip, with subsequent slipping of the piston.



Shea piston

14

15

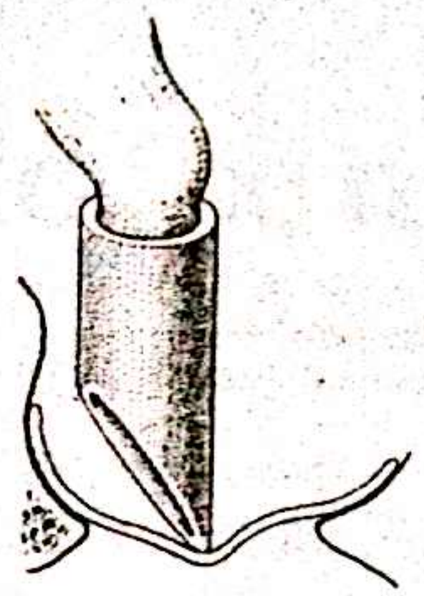
Total stapedectomy

Some otologists still prefer total removal of the whole footplate, except in cases of obliterative otosclerosis, and it is argued that this is less likely to give rise to perilymphatic fistulae.

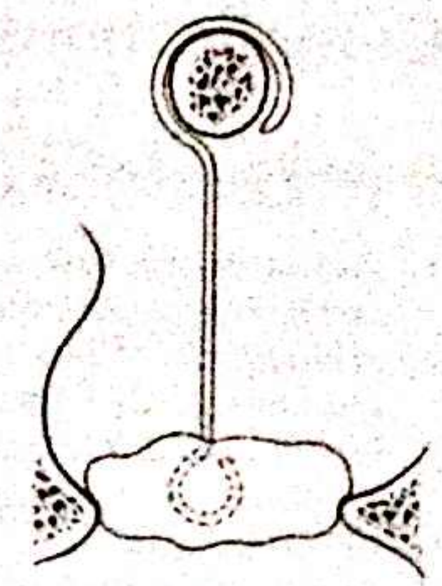
The original technique of Shea (*a*), in which the oval window was sealed by a vein graft, and a flanged polyethylene strut was inserted between the graft and the lenticular process of the incus, is now rarely used, as the prosthesis may cause incus necrosis; there have also been several reports of 'dead ears' following delayed penetration of the graft by the tip of the strut.

Alternatively, the oval window may be temporarily sealed by a piece of fat (*b*) or Gelfoam (*c*) attached to a wire (Schuknecht) and hooked over the incus, or a single or double wire loop (*d*) can be placed on to compressed Gelfoam (House).

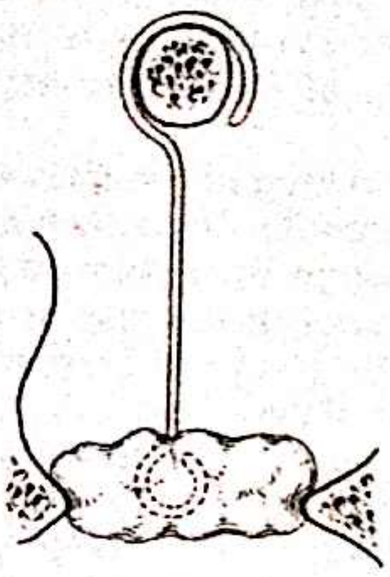
In the Portmann interposition operation (e) the stapes superstructure and stapedius tendon are preserved and the posterior crus is placed on to a vein graft which seals the oval window. It is claimed that preservation of the stapedius muscle protects the cochlea from subsequent noise trauma and that preservation of the incudostapedial joint capsule prevents necrosis of the incudal tip. However, this operation is technically much more difficult than all others and it is not always possible.



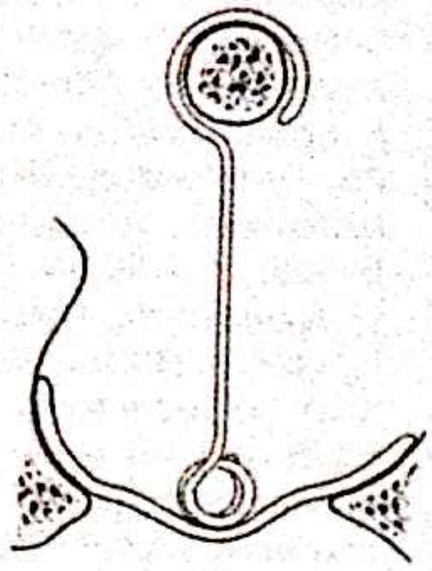
15a



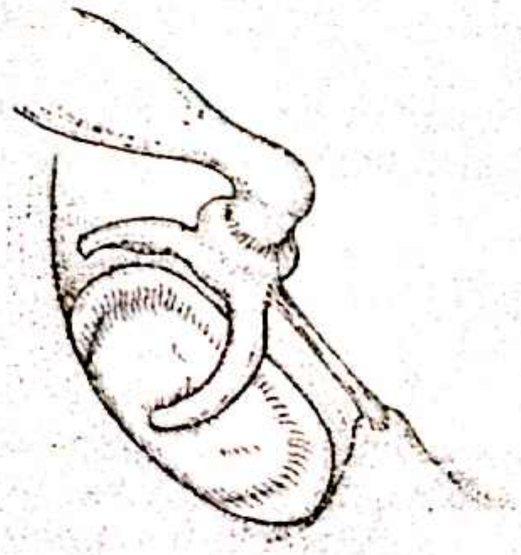
15b



15c



15d



15e

Treatment of the mobilized footplate

Rarely, when the footplate is uniformly thickened but not obliterated, attempts to penetrate it with a needle may result in free mobilization. Unless it is possible to introduce an angled hook under a presenting edge, or if attempts to lift it out threaten to tilt it, it should be left in its natural but slightly depressed position and covered with mesenchymal tissue, e.g. vein, fascia or periosteum. This is connected to the incus with a House-type wire loop prosthesis. Alternatively, a piston may be placed on the mobilized footplate and surrounded by fat. This often produces surprisingly good hearing results.

Treatment of delayed postoperative conductive hearing loss

A delayed conductive hearing loss occurring months or years after an initially successful stapedectomy suggests prosthesis failure.

If the prosthesis has simply slipped, it may be possible to remove it and replace it with another; if the incus is severely necrosed, satisfactory hearing may be restored by using a prosthesis from the malleus to the oval window.

Postoperative care

Systemic antibiotic cover is given routinely for the first 5 days after stapedectomy, and prochlorperazine (Stemetil) 5 mg is given as required for the mild vertigo which may occur in the first 2 or 3 postoperative days. When a hypotensive anaesthetic has been used, the bed is kept flat until the patient is normotensive. He should not leave his bed without support until the balance is stable, and is advised not to blow his nose for the first 4 or 5 days. Flying and swimming are discouraged for 4 weeks.

Recovery of hearing may be delayed for some weeks, and in rare instances for several months after surgery.

Complications

Immediate or early

1. *Distortion or loss of taste* may occur as a result of stretching or section of the chorda tympani.
2. *Perforation of the tympanic membrane* usually heals spontaneously when it is small.
3. *Otitis media* is a rare complication which will usually respond to a change of antibiotic but may require myringotomy.
4. *Facial palsy*, immediate or delayed, is fortunately very rare. When immediate, it calls for early surgical exploration. (The bony Fallopian canal is congenitally defective in approximately 6 per cent of persons, usually over the inferior aspect of the horizontal tympanic portion of the nerve.)
5. *Persistent vertigo* may be due to too long or too short a prosthesis; it may also be a symptom of perilymph fistula. It calls for further exploration by a permeatal tympanotomy. (Reduction or absence of the response to caloric stimulation may persist for months or years after stapedectomy in 10 per cent of patients.)
6. *High-frequency hearing loss* is more likely to occur when the stapedial crura are so strong that the whole stapes is avulsed from the oval window as the surgeon attempts to fracture them.
7. *Fluctuating sensorineural hearing loss* always suggests a fistula. If not recognised and repaired, it may lead to a 'dead ear'.

Delayed complications

1. *'Dead ear'* may result from a perilymph fistula or occur many months or years after surgery, sometimes for no apparent reason. Penetration of the membranous labyrinth by the prosthesis is the commonest of the recorded causes of such a delayed severe sensorineural hearing loss. A total or sub-total loss occurring immediately after the operation is usually due to technical failure.

   'Dead ear' occurs in as many as 2 per cent of all stapedectomies.
2. *Delayed conductive hearing loss* is usually caused by prosthesis failure due either to slipping of the prosthesis or to necrosis of the incus.

Illustrations by Lesley Skeates

Surgical approaches to the middle ear and mastoid

P. M. Shenoi ChM, FRCS, FRCS(Ed), DLO
Consultant Ear, Nose and Throat Surgeon, East Birmingham Hospital, Bordesley Green East, Birmingham, UK

PERMEATAL APPROACH (LATERAL TYMPANOTOMY)

Preoperative

Indications

Exploration of the middle ear cleft is probably best carried out through a permeatal approach, as this allows inspection of the middle ear space under sterile conditions and, following completion of surgical manoeuvres, isolation of the middle ear space from the exterior. The permeatal approach may be used for:

1. examination of the ossicular chain in congenital conductive deafness;
2. stapedectomy for otosclerotic fixation of the stapes;
3. revision stapedectomy;
4. correction of post-stapedectomy perilymph fistula and/or oval window granuloma;
5. ossicular chain reconstruction for traumatic disconnection or as a planned second stage of a tympanoplasty 6–12 months after the perforation has been closed;
6. closure of a perforated tympanic membrane in cases where an in-lay graft technique is to be used;
7. destruction of the membranous labyrinth, as in uncontrolled unilateral Menière's disease associated with severe sensorineural deafness and post-stapedectomy 'dead ear' associated with uncontrollable vertigo;
8. tympanic neurectomy for recurrent sialadenitis of the parotid gland and uncontrolled 'crocodile tears' following lower motor neurone facial paralysis;
9. removal of a glomus tympanicum;
10. repair of the round window membrane after spontaneous rupture;
11. singular nerve neurectomy in uncontrolled benign positional nystagmus;
12. section of the cochlear division of the VIIIth nerve in selected cases with tinnitus.

Contraindications

Permeatal tympanotomy should never be attempted in the presence of either diffuse or localized external otitis.

Investigations

An up-to-date preoperative audiogram is essential, and a full blood count, ECG and chest X-ray are desirable in view of the planned hypotensive anaesthesia.

Preparation of the ear

The correct ear is identified. Wax is cleared from the external auditory canal and any hairs in the meatal opening are clipped. The hair is shaved for a distance of about 2.5 cm around the ear. This also helps to identify the correct ear at operation.

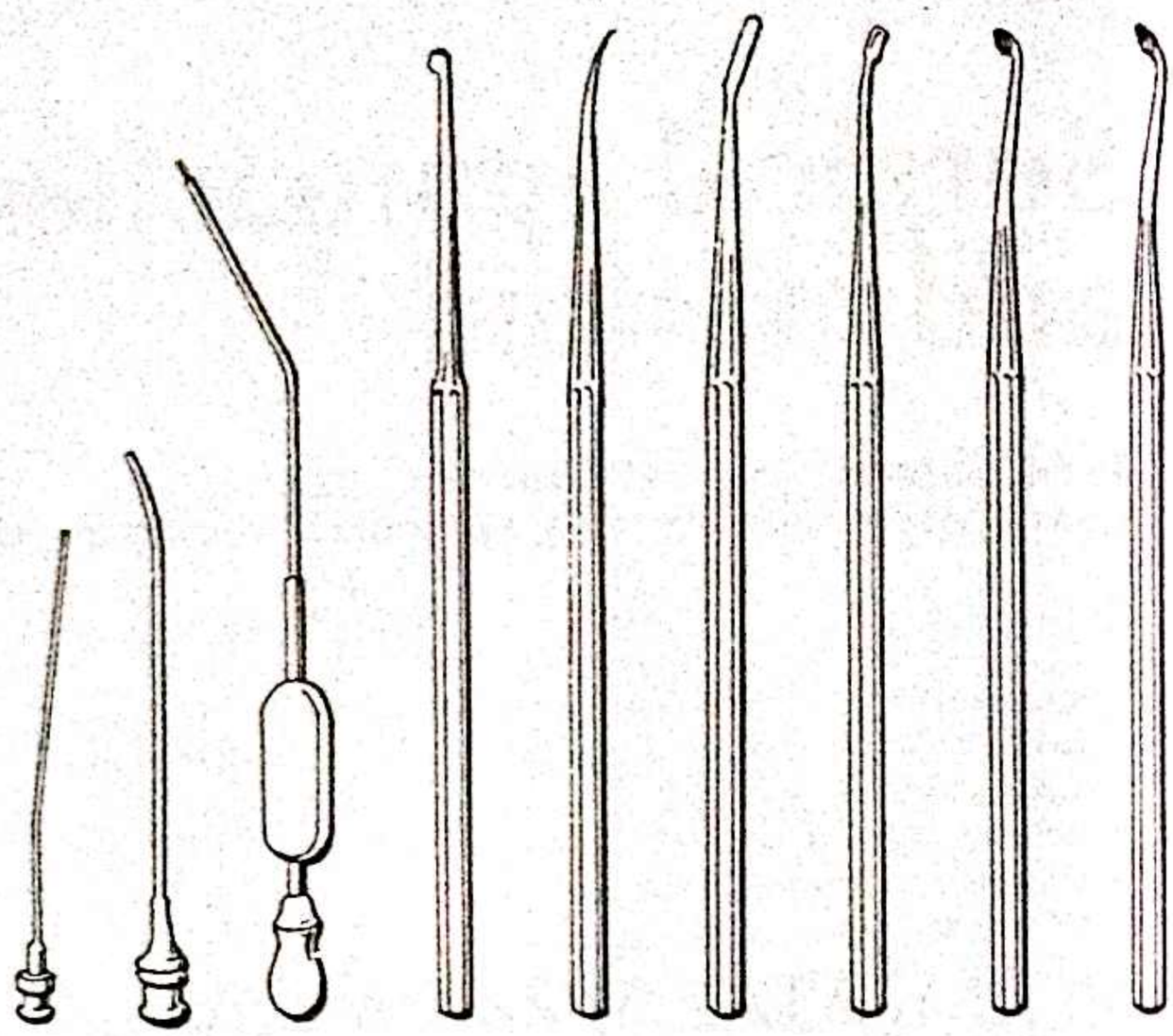
Anaesthesia

Local anaesthesia with 1 per cent lignocaine (Xylocaine) in 1:200 000 adrenaline is used in some centres, although we prefer general hypotensive anaesthesia. This requires premedication, for which we use Lorazepan 2–4 mg. Controlled hypotensive general anaesthesia with endotracheal intubation is used throughout. An intravenous drip is maintained and pulse rate and ECG monitored throughout the procedure.

1

Instrumentation

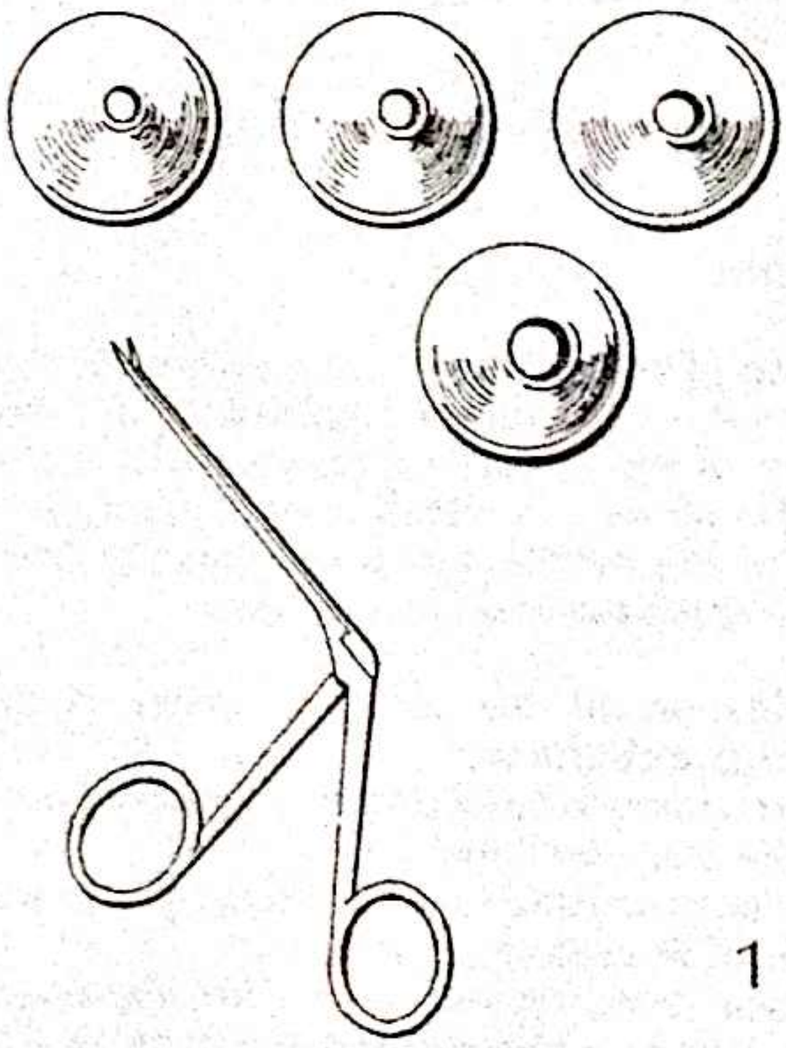
In addition to the binocular operating microscope (Zeiss), the following instruments are needed: a full range of black aural specula; suction tubes of Zöliner and Rosen types; first incision knife – the author prefers a combination of Plester and Cawthorne types; angled blunt elevator (Rosen); a curved needle (Rosen); coarse and fine bone curettes (Rosen); fine crocodile forceps with serrated jaws (Hartmann); self-retaining speculum holder.



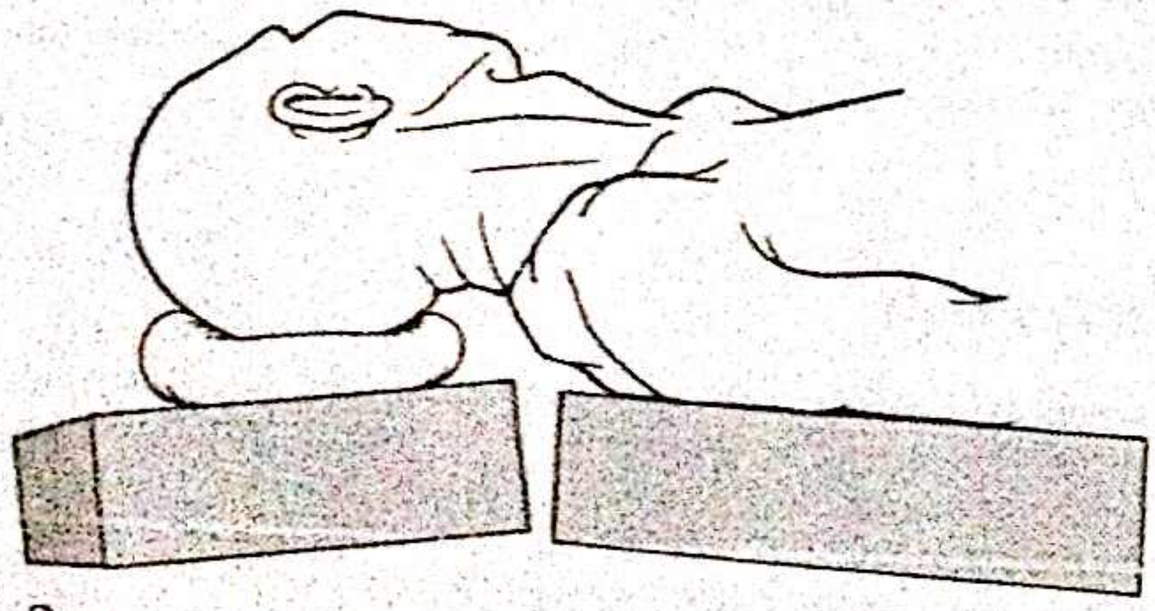
Surgical anatomy

The external auditory canal is 24 mm in length; it is cartilaginous in its outer third and osseous in its inner two-thirds. It is S-shaped, with the cartilaginous part directed upwards, backwards and medially, and the osseous part directed medially and forwards with a gentle downward slope. The anterior wall of the canal is longer than the posterior wall. Often the anterior aspect of the tympanic membrane is obscured by a bony bulge (canal hump). There are two natural constrictions along the canal, one at the junction of the cartilage with the bony canal, the other more medially, at the isthmus, about 5 mm from the edge of the tympanic membrane.

The tympanic membrane is pearly-grey, thin and translucent, broader superiorly and ovoid in shape. It is obliquely placed and is concave on its outer surface. The handle of the malleus is directed downwards and slightly backwards, with its tip projecting towards the middle ear cavity.



1



2

2

Position of patient

The patient is placed supine on the operating table, with the head supported on a rubber ring and rotated to the opposite side. The entire table is tilted head-up for 30°. The neck is extended 10°. The ear is cleaned with cetrimide and sterile drapes are applied. Self-adhesive Steridrape is very useful. A comfortable seat for the operator is essential.

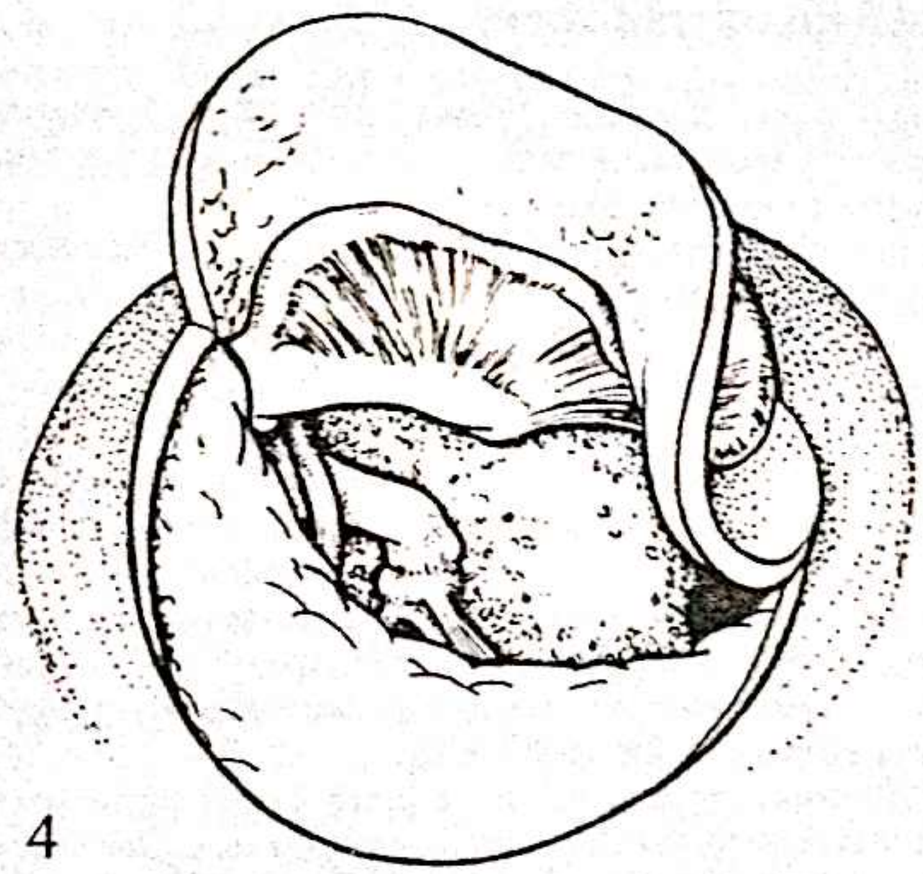
The approach

3

The incision

A suitably sized black aural speculum is inserted into the external auditory canal and the remaining cetrimide solution is cleared by gentle suction, under the microscope with ×6 magnification. A speculum holder can be used to hold the speculum in place.

An incision is made in the posterior canal skin with a first incision knife, extending approximately from the 12 o'clock position superiorly to the 6 o'clock position inferiorly, and curving outwards to the level of the isthmus at its midpoint. Any bleeding is controlled by a Rosen suction tube.



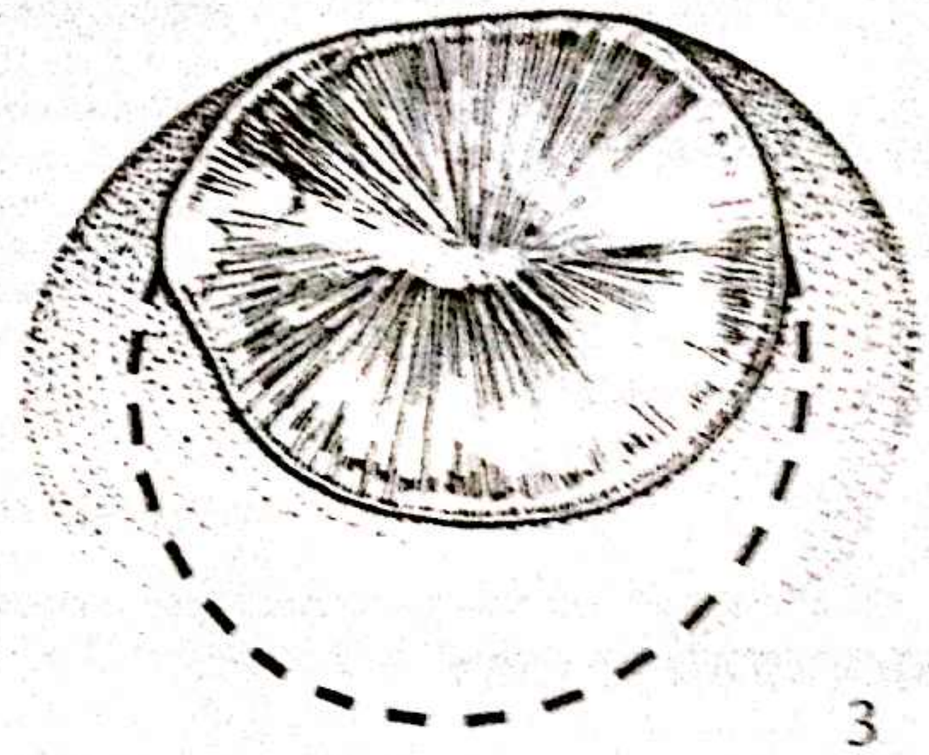
4

5

Middle ear cavity

Having exposed the posterior half of the middle ear cavity, the promontory is identified in its medial wall. The chorda tympani is seen passing forwards from the posterior canaliculus for the chorda tympani nerve and is situated immediately behind the tympanic membrane, in line with the upper end of the handle of the malleus. The nerve is gently reflected downwards with a curved needle to identify the long process of the incus, the incudostapedial joint and the oval window region. The oval window is above and behind the promontory, and the round window is below and behind the promontory.

To expose the posterosuperior part of the middle ear cavity fully, the deep bony meatal wall is reduced with a fine hand curette. The stapedius tendon and the pyramidal process together with the stapes and oval window can now be clearly seen. The horizontal portion of the facial nerve canal is seen just above the oval window, and its bony covering is dehiscent in approximately 6 per cent of persons.

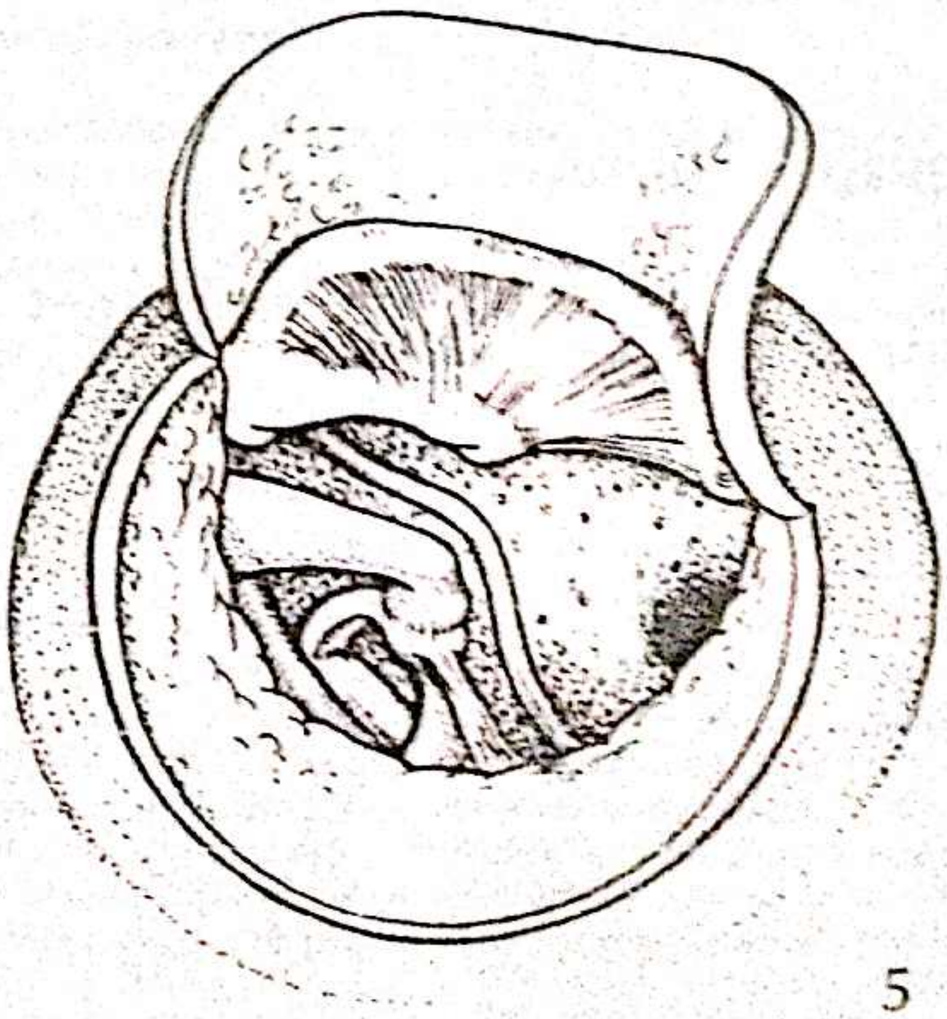


3

4

Reflection of the tympanomeatal flap

The posterior canal skin together with the periosteum is reflected forwards with a blunt angled elevator. It is easier to commence dissection posterosuperiorly where the canal skin is several millimetres thick. The skin flap is reflected forwards until the fibrous annulus is identified. Small pledgets of dry cotton wool placed over the advancing edge of a blunt dissection often aid haemostasis and make reflection of the flap easier. The fibrous annulus is elevated from the bony sulcus, beginning posterosuperiorly, and the posterior canal skin together with the posterior half of the pars tensa is then reflected forwards to expose the posterior part of the mesotympanum. A pledget of dry cotton wool is placed over the anterior surface of the tympanic membrane over the handle of malleus to help maintain the folded tympanomeatal flap forwards.



5

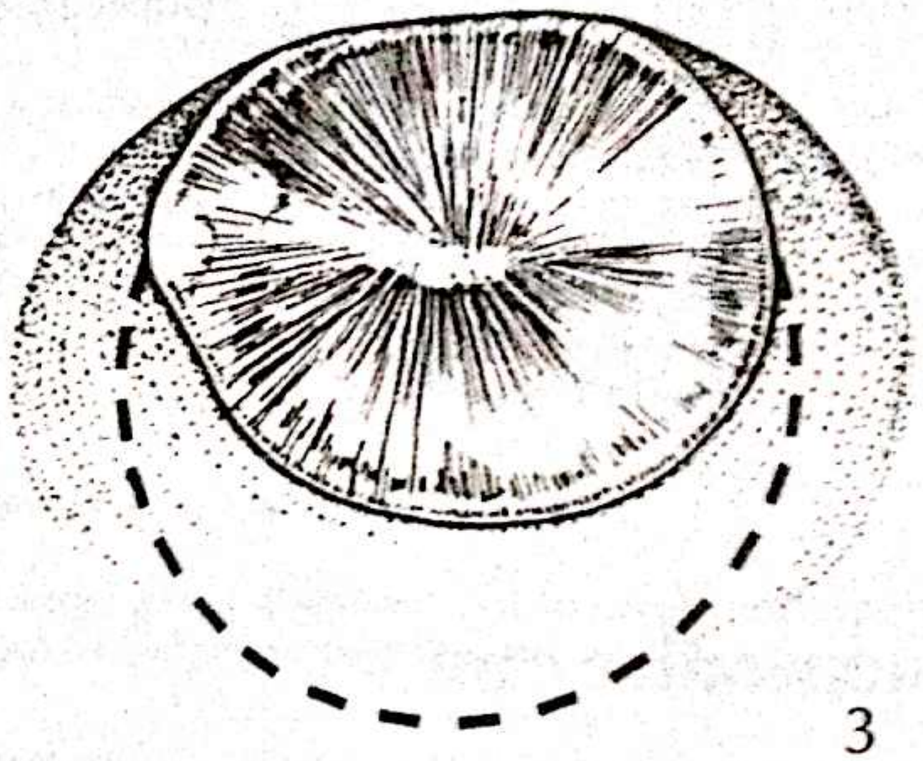
The approach

3

The incision

A suitably sized black aural speculum is inserted into the external auditory canal and the remaining cetrimide solution is cleared by gentle suction, under the microscope with ×6 magnification. A speculum holder can be used to hold the speculum in place.

An incision is made in the posterior canal skin with a first incision knife, extending approximately from the 12 o'clock position superiorly to the 6 o'clock position inferiorly, and curving outwards to the level of the isthmus at its midpoint. Any bleeding is controlled by a Rosen suction tube.

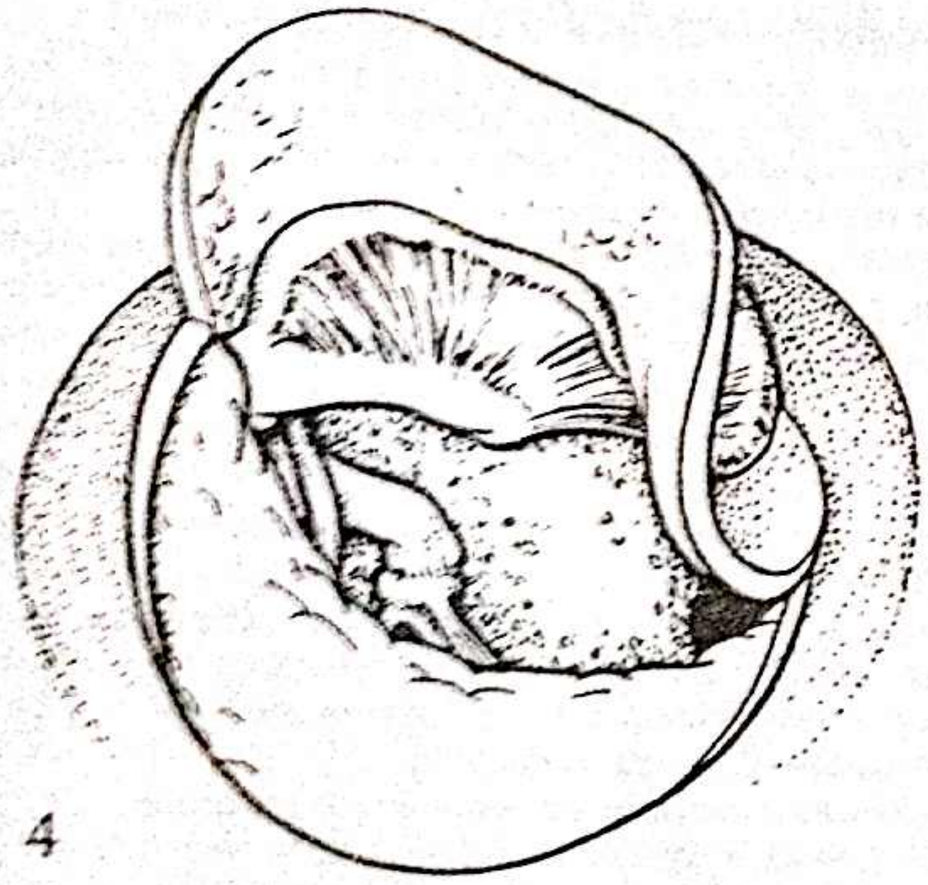


3

4

Reflection of the tympanomeatal flap

The posterior canal skin together with the periosteum is reflected forwards with a blunt angled elevator. It is easier to commence dissection posterosuperiorly where the canal skin is several millimetres thick. The skin flap is reflected forwards until the fibrous annulus is identified. Small pledgets of dry cotton wool placed over the advancing edge of a blunt dissection often aid haemostasis and make reflection of the flap easier. The fibrous annulus is elevated from the bony sulcus, beginning posterosuperiorly, and the posterior canal skin together with the posterior half of the pars tensa is then reflected forwards to expose the posterior part of the mesotympanum. A pledget of dry cotton wool is placed over the anterior surface of the tympanic membrane over the handle of malleus to help maintain the folded tympanomeatal flap forwards.



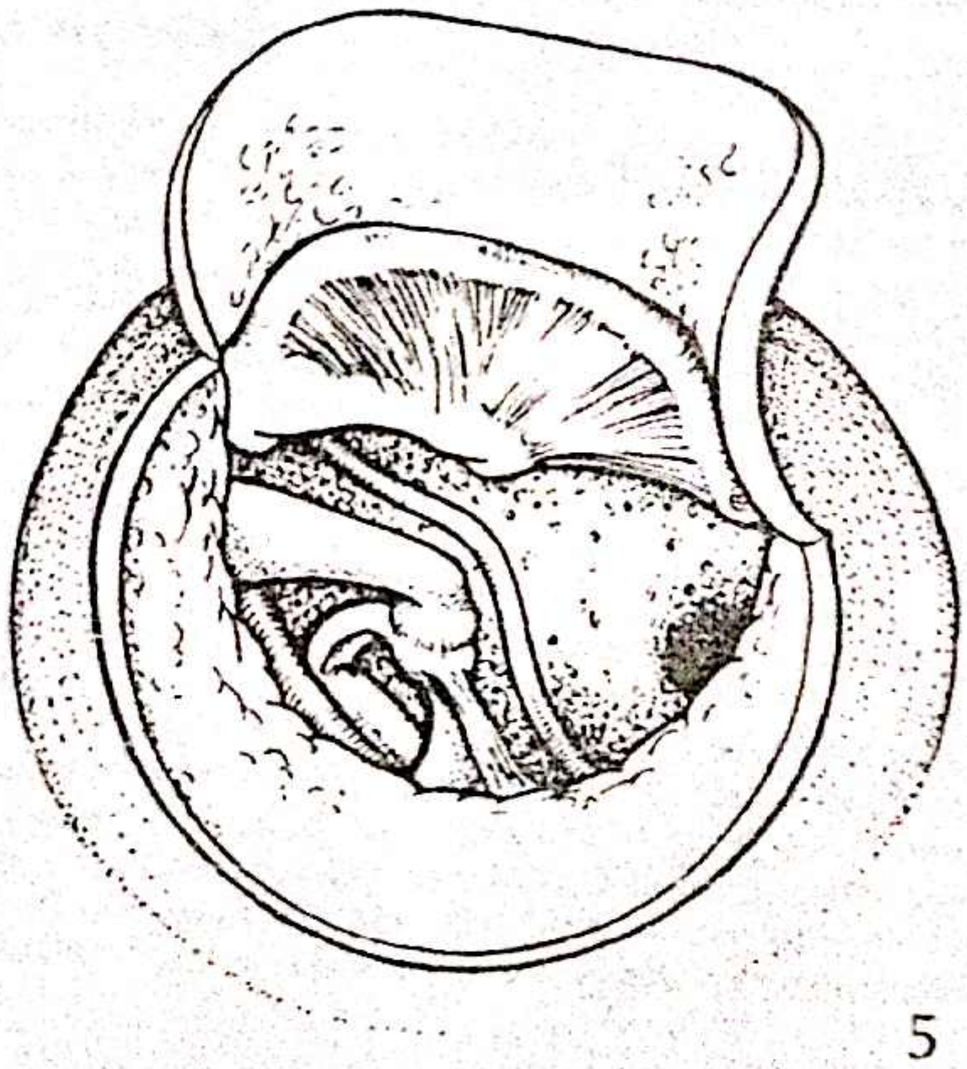
4

5

Middle ear cavity

Having exposed the posterior half of the middle ear cavity, the promontory is identified in its medial wall. The chorda tympani is seen passing forwards from the posterior canaliculus for the chorda tympani nerve and is situated immediately behind the tympanic membrane, in line with the upper end of the handle of the malleus. The nerve is gently reflected downwards with a curved needle to identify the long process of the incus, the incudostapedial joint and the oval window region. The oval window is above and behind the promontory, and the round window is below and behind the promontory.

To expose the posterosuperior part of the middle ear cavity fully, the deep bony meatal wall is reduced with a fine hand curette. The stapedius tendon and the pyramidal process together with the stapes and oval window can now be clearly seen. The horizontal portion of the facial nerve canal is seen just above the oval window, and its bony covering is dehiscent in approximately 6 per cent of persons.

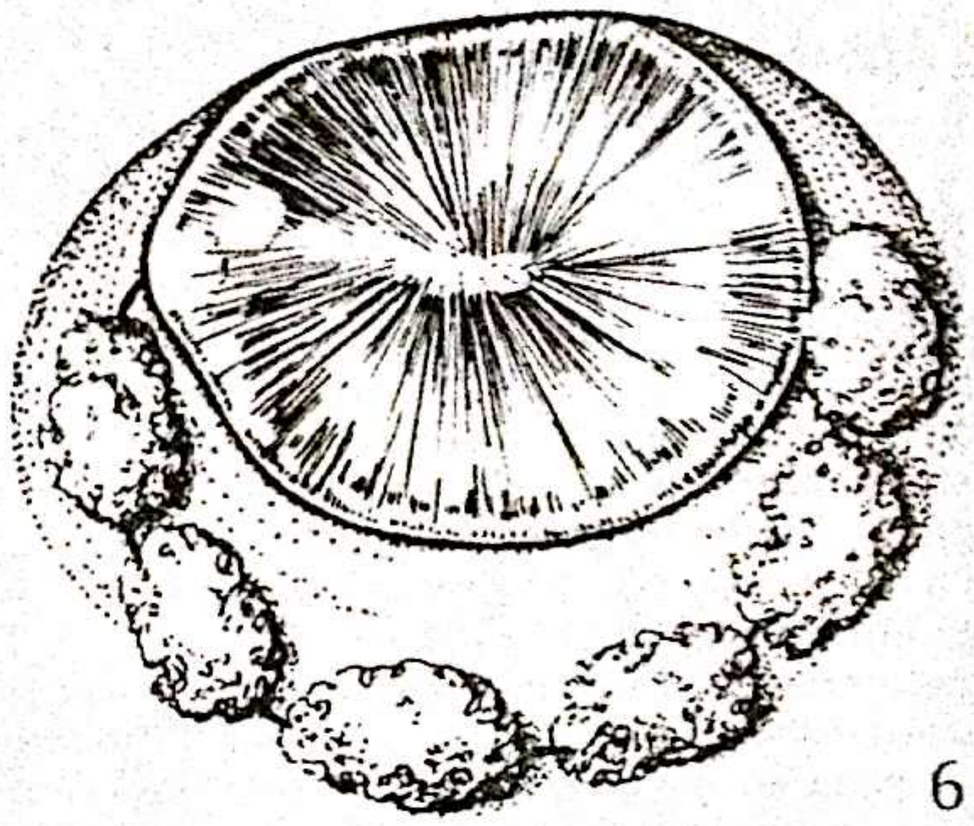


5

6

Closure of wound

At the end of the surgical procedure the tympanomeatal flap is replaced and the incision line is sealed with gelatin sponge (Sterispon). A light pack in the external auditory canal may be necessary in some cases.



6

Postoperative care

If there is reason to believe that the patient is likely to develop vertigo, it is advisable to administer prochlorperazine (Stemetil) 12.5 mg intramuscularly before the patient is transferred to the ward.

Once in the ward the patient is kept supine or on his side, with the operated ear uppermost and one pillow supporting the head. Blood pressure is monitored every half hour. At the end of 24 hours, by which time it should have returned to normal, the patient is allowed to sit up. Mobilization depends on the degree of postoperative vertigo, which if present is treated with suitable vestibular sedatives (cinnarazine 15 mg or prochlorperazine 5 mg three times a day). Blowing the nose is discouraged for a few days. In ladies, haircare is best deferred until the wound in the meatus is fully healed. Antibiotic cover may be desirable, depending on the definitive procedure.

Driving

The patient is not allowed to drive a motor car until free from vestibular disorder. In the United Kingdom it is an offence to drive while suffering from vertigo. Patients are also asked not to swim, climb ladders or scaffolding or handle heavy machinery until free of vertigo.

Complications

Only complications relating to this approach rather than to any specific intratympanic operative procedure are mentioned.

Immediate complications

1. *Facial nerve paralysis*. Before the patient leaves the recovery area, facial nerve function should be checked on the operated side.
2. *Acute suppurative otitis media* can prove disastrous to the hearing. Systemic broad spectrum antibiotic cover, usually with amoxycillin in the absence of hypersensitivity, is advisable for 5 to 7 days postoperatively.
3. *Perforation of the tympanic membrane* is likely if there are minor lacerations over the posterior part of the drum during reflection of the tympanomeatal flap.
4. *'Dead ear'* may occur within a few days of tympanotomy in certain circumstances. It is worth recording here that absorbable gelatin sponge (Sterispon) no longer contains formaldehyde since the manufacturing process was altered in the mid-1970s.
5. *Distortion or loss of taste* may occur as a result of laceration or division of the chorda tympani nerve.
6. *Persistent bleeding* from the external auditory canal, especially when the blood pressure is returning to normal, may be helped by a light BIPP pack in the external auditory canal.

Delayed complications

1. *'Dead ear'* occurring many months after surgery.
2. Persistent vertigo associated with a 'dead ear'.
3. Persistent perforations of the tympanic membrane.

ENDAURAL APPROACH

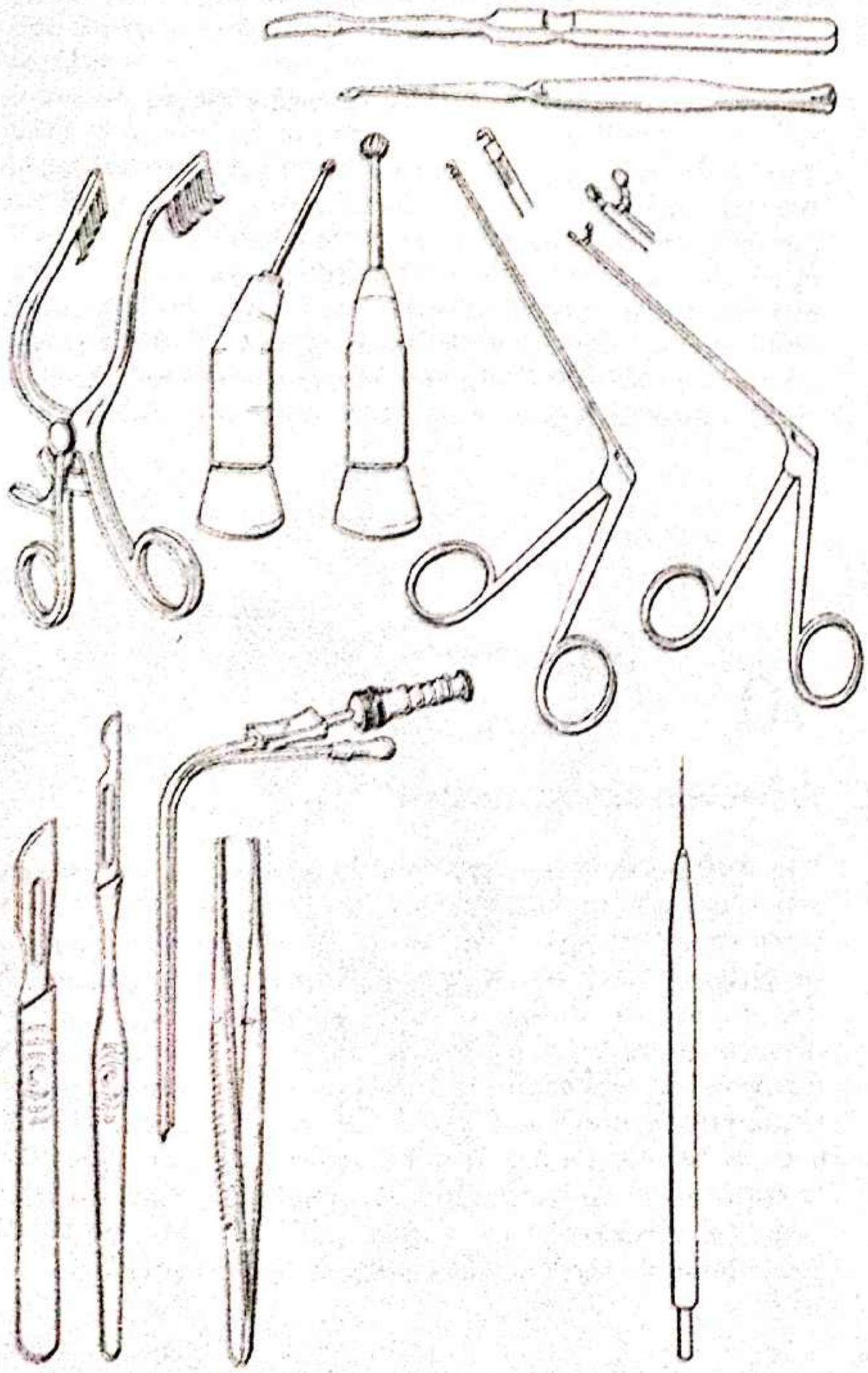
Preoperative

Indications

The endaural approach provides direct 'head-on' access to the mesotympanum, epitympanum, aditus and antrum. It is used mainly for the eradication of cholesteatoma in the epitympanum and surgical correction of acquired meatal stenosis, and occasionally for a modified radical mastoidectomy in a small acellular mastoid. It is used less frequently for gaining access to the middle ear cleft, as during tympanoplasty, and for stapedectomy in the presence of a narrow external auditory canal. It may also be used for fenestration of the horizontal semicircular canal.

Disadvantages

There is a tendency to stenosis formation at the junction between the bony and cartilaginous external auditory canal. Occasionally it is difficult to gain access to the mastoid tip cells.



7

Investigations

An up-to-date preoperative audiogram is essential. Standard X-ray films of the mastoid help to identify a forwardly-placed sigmoid sinus and to determine the height of the dural plate. General investigations are as for the permeatal approach. In addition, if the ear is infected, a swab is obtained for culture and sensitivity determination. A sickle cell test is carried out where appropriate.

Preparation of ear

The correct ear is identified and the hair is shaved for a distance of 5–7 cm around the ear.

Anaesthesia

As for the permeatal approach. Local infiltration with 1 per cent lignocaine in 1:200000 adrenaline along the line of the incision may be contraindicated if halothane is used.

7

Instrumentation

Apart from the binocular operating microscope, the following are needed: a suitable head light; Bard-Parker knife handle with No. 10 and 15 blades; fine dissecting forceps; diathermy lead and electrode; a high speed electric or pneumatic drill with a minimum speed of 10000 to 20000 r/min; straight and angled drill hand pieces; a full range of cutting burrs; suction tubes of Zöllner and Rosen types; continuous suction-irrigation tube (House); self-retaining retractors (Mollison); broad and narrow rougine (Lempert); malleus head guillotine forceps (Wishart); crocodile cup aural forceps (Shea); angled elevator; coarse and fine bone curettes; fine crocodile forceps with serrated jaws; curved needle (see Permeatal approach).

Surgical anatomy

The cartilaginous external auditory canal is attached by fibrous tissue to the circumference of the osseous meatal opening except in the anterosuperior part. It is this cartilage-free gap, filled with fibrous tissue, between the anterior end of the helix posteriorly and the tragus anteriorly, that allows a suitable incision to be made without damaging the cartilage.

The mastoid antrum lies at a depth of about 1.25 cm from the surface, medial to the suprameatal triangle (of MacEwen). This triangle is bounded superiorly by the anterior end of the supramastoid crest, anteroinferiorly by the curved posterosuperior margin of the bony meatus, and posteriorly by a vertical tangent from the supramastoid crest to the posterior margin of the bony meatus. The anterior part of this depression is usually marked by a bony projection called the suprameatal spine (of Henle).

In infants and younger children, before the development of the mastoid tip, the antrum is only a few millimetres deep and placed much more forward than in adults.

ENDAURAL APPROACH

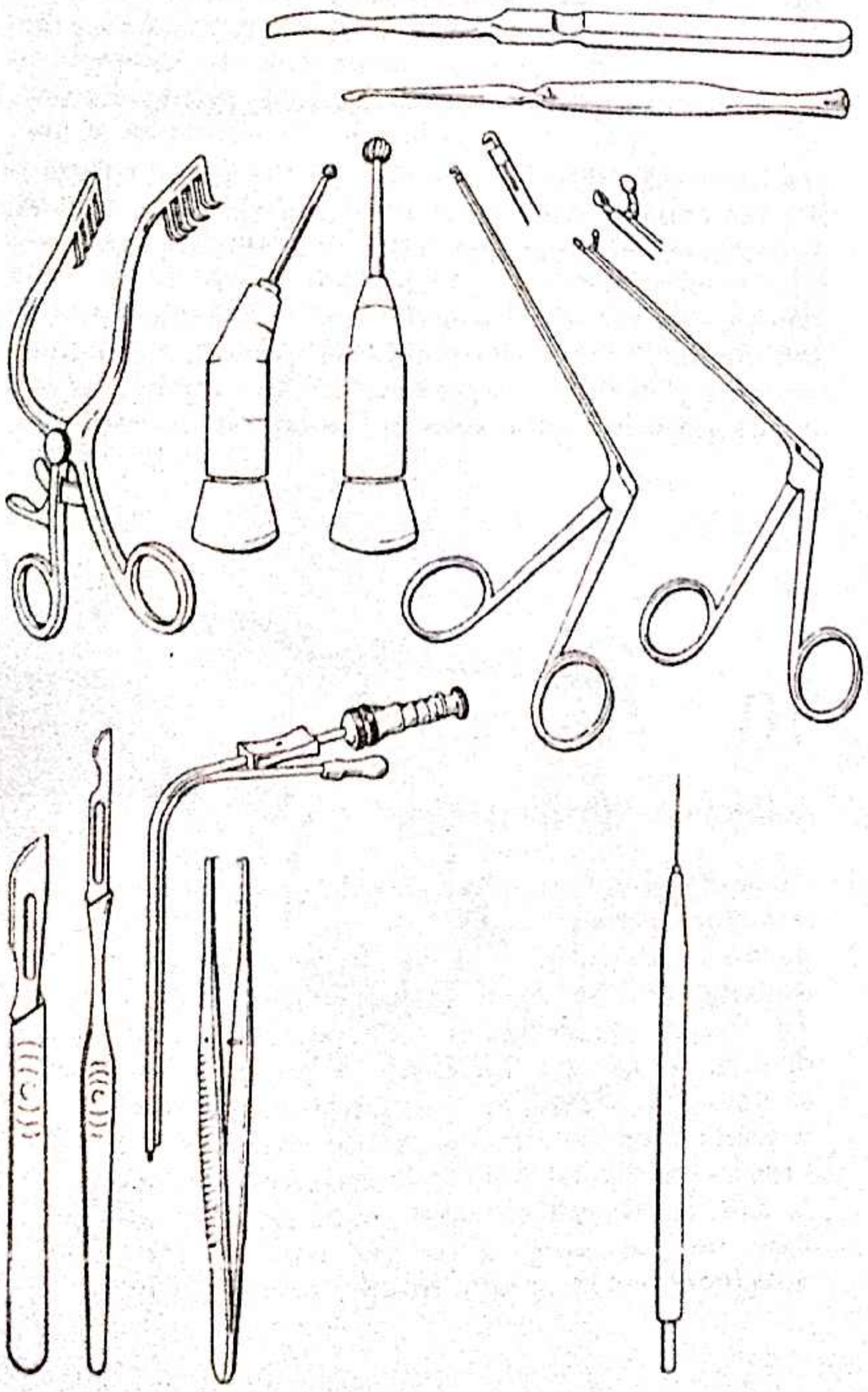
Preoperative

Indications

The endaural approach provides direct 'head-on' access to the mesotympanum, epitympanum, aditus and antrum. It is used mainly for the eradication of cholesteatoma in the epitympanum and surgical correction of acquired meatal stenosis, and occasionally for a modified radical mastoidectomy in a small acellular mastoid. It is used less frequently for gaining access to the middle ear cleft, as during tympanoplasty, and for stapedectomy in the presence of a narrow external auditory canal. It may also be used for fenestration of the horizontal semicircular canal.

Disadvantages

There is a tendency to stenosis formation at the junction between the bony and cartilaginous external auditory canal. Occasionally it is difficult to gain access to the mastoid tip cells.



7

Investigations

An up-to-date preoperative audiogram is essential. Standard X-ray films of the mastoid help to identify a forwardly-placed sigmoid sinus and to determine the height of the dural plate. General investigations are as for the permeatal approach. In addition, if the ear is infected, a swab is obtained for culture and sensitivity determination. A sickle cell test is carried out where appropriate.

Preparation of ear

The correct ear is identified and the hair is shaved for a distance of 5–7 cm around the ear.

Anaesthesia

As for the permeatal approach. Local infiltration with 1 per cent lignocaine in 1:200 000 adrenaline along the line of the incision may be contraindicated if halothane is used.

7

Instrumentation

Apart from the binocular operating microscope, the following are needed: a suitable head light; Bard-Parker knife handle with No. 10 and 15 blades; fine dissecting forceps; diathermy lead and electrode; a high speed electric or pneumatic drill with a minimum speed of 10 000 to 20 000 r/min; straight and angled drill hand pieces; a full range of cutting burrs; suction tubes of Zöllner and Rosen types; continuous suction-irrigation tube (House); self-retaining retractors (Mollison); broad and narrow rougine (Lempert); malleus head guillotine forceps (Wishart); crocodile cup aural forceps (Shea); angled elevator; coarse and fine bone curettes; fine crocodile forceps with serrated jaws; curved needle (see Permeatal approach).

Surgical anatomy

The cartilaginous external auditory canal is attached by fibrous tissue to the circumference of the osseous meatal opening except in the anterosuperior part. It is this cartilage-free gap, filled with fibrous tissue, between the anterior end of the helix posteriorly and the tragus anteriorly, that allows a suitable incision to be made without damaging the cartilage.

The mastoid antrum lies at a depth of about 1.25 cm from the surface, medial to the suprameatal triangle (of MacEwen). This triangle is bounded superiorly by the anterior end of the supramastoid crest, anteroinferiorly by the curved posterosuperior margin of the bony meatus, and posteriorly by a vertical tangent from the supramastoid crest to the posterior margin of the bony meatus. The anterior part of this depression is usually marked by a bony projection called the suprameatal spine (of Henle).

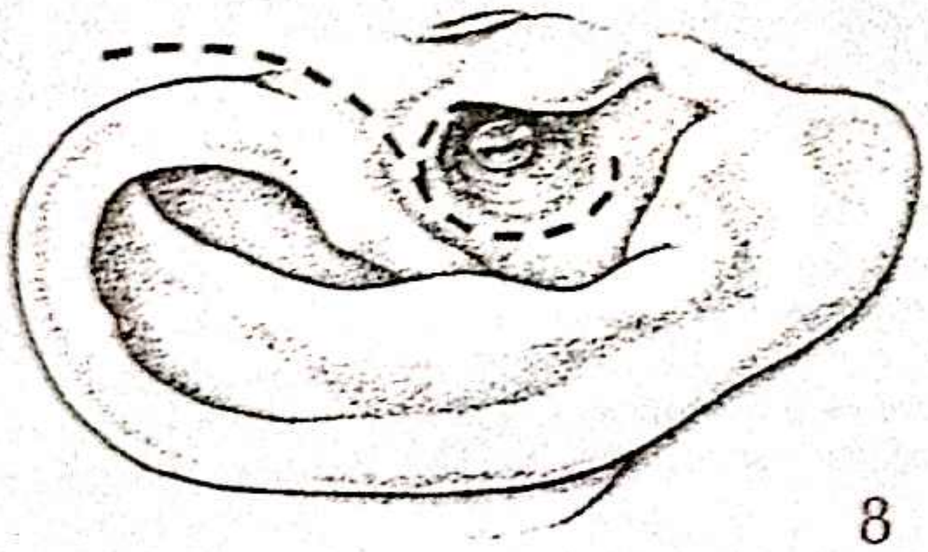
In infants and younger children, before the development of the mastoid tip, the antrum is only a few millimetres deep and placed much more forward than in adults.

The approach

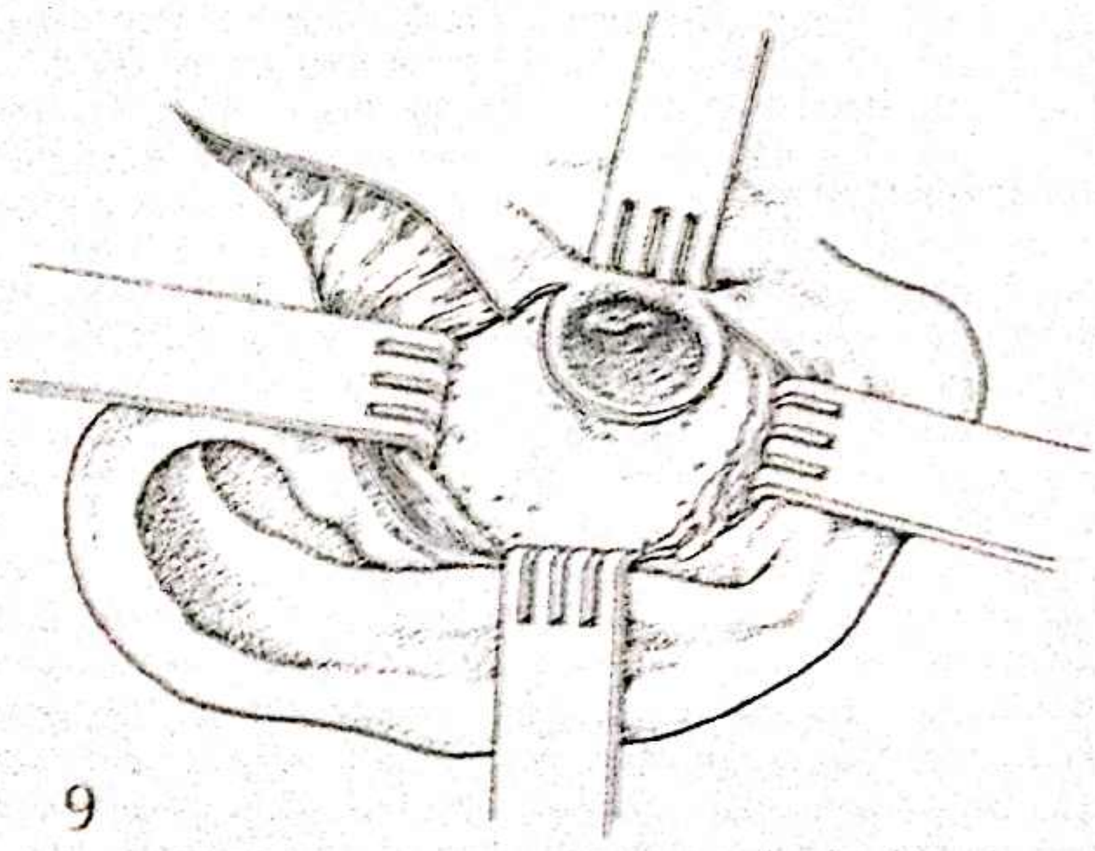
8

The incision

With the patient positioned as for the permeatal approach, the upper part of the incision is made in the cartilage-free gap described above. It is deepened inferiorly until the superior part of the bony meatus is reached and extended superiorly, parallel to the ascending limb of the helix. The temporalis fascia is exposed in the depth of this part of the incision. The lower part of the incision is made at the junction of the cartilaginous with the bony meatus and forms three-quarters of a circle, starting at the 3 o'clock position and continuing through 12 o'clock to reach the floor at the 6 o'clock position.



8

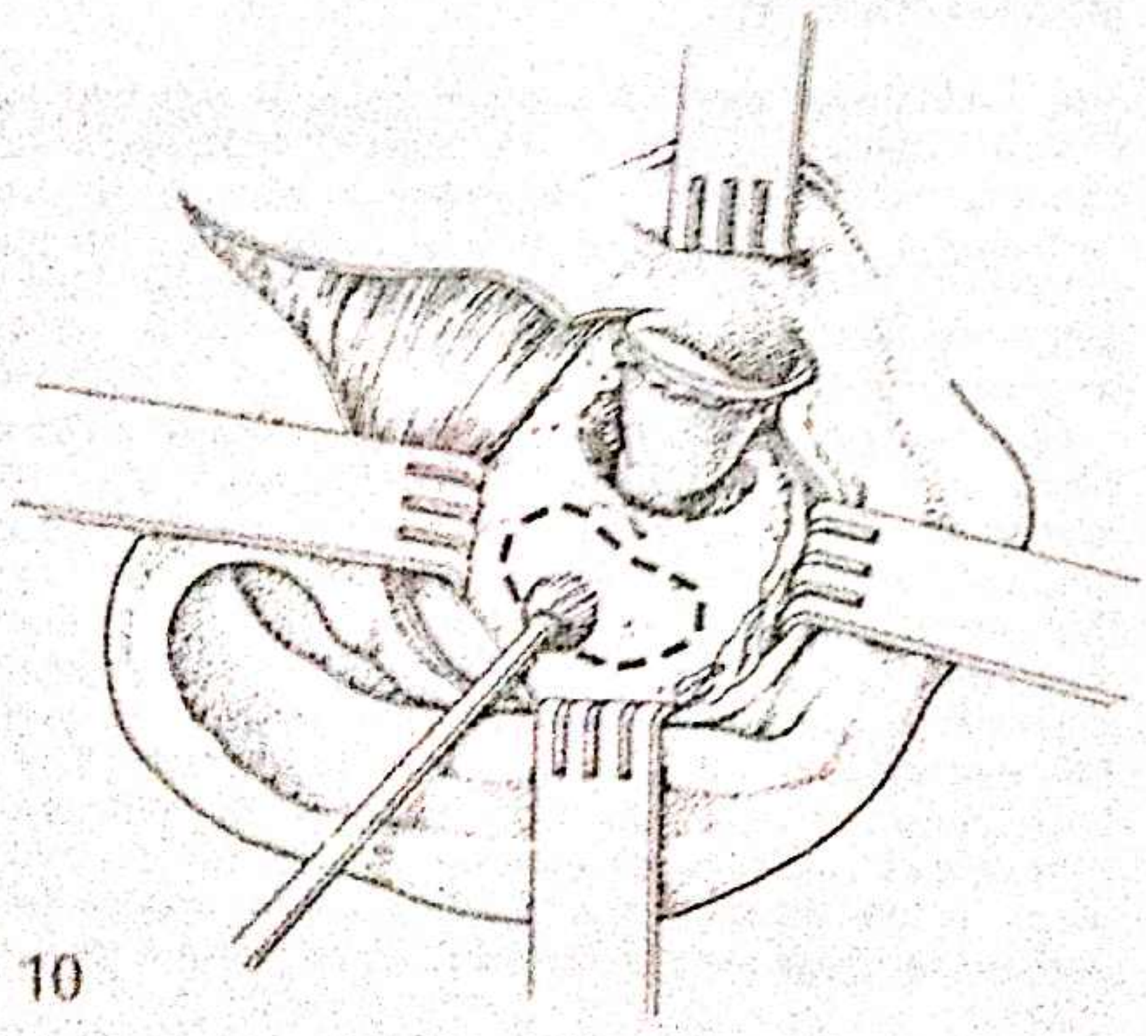


9

9

Exposure of mastoid and temporalis fascia

The lower meatal part of the incision is deepened through the periosteum until the meatal bone is felt, and the periosteum is separated from the underlying bone, upwards and backwards, with a periosteal elevator. This exposes the suprameatal spine, the suprameatal triangle and the bony cortex of the mastoid process from antero posteriorly. Self-retaining retractors, usually two at right angles, provide a good view of the operative field.



10

10

Reflection of meatal skin

The temporalis muscle is retracted upwards with a second retractor and mobilization of the meatal skin is commenced posteriorly, where it is reflected from the underlying bone down to the tympanic ring. Superiorly the thicker canal skin is reflected downwards and the dissection carried forwards. Especial care must be exercised in separating the skin from the anterosuperior (squamotympanic) and posterior (tympanomastoid) sutures as the meatal flap is rolled downwards and forwards to expose the epitympanum. In acquired meatal atresia it may be necessary to excise part of the thickened subcutaneous layer until healthy skin is reached.

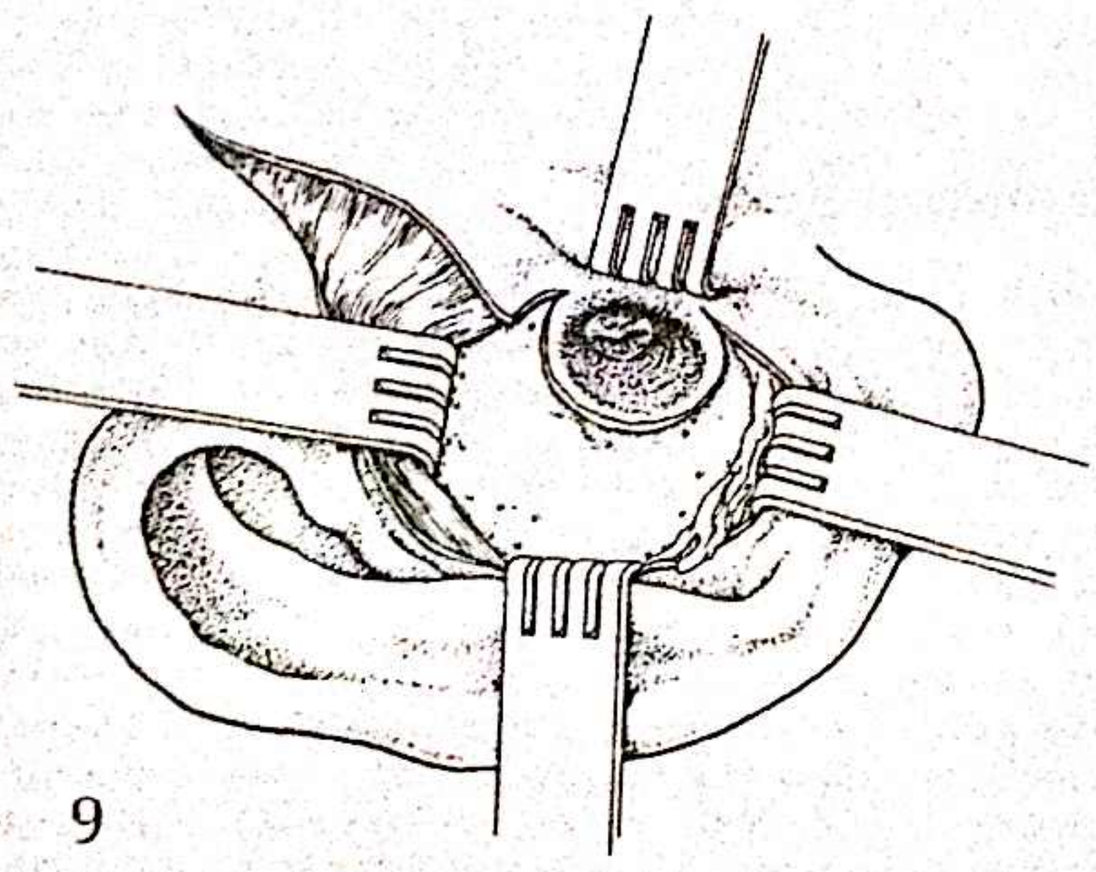
The approach

8

The incision

With the patient positioned as for the permeatal approach, the upper part of the incision is made in the cartilage-free gap described above. It is deepened inferiorly until the superior part of the bony meatus is reached and extended superiorly, parallel to the ascending limb of the helix. The temporalis fascia is exposed in the depth of this part of the incision. The lower part of the incision is made at the junction of the cartilaginous with the bony meatus and forms three-quarters of a circle, starting at the 3 o'clock position and continuing through 12 o'clock to reach the floor at the 6 o'clock position.

8

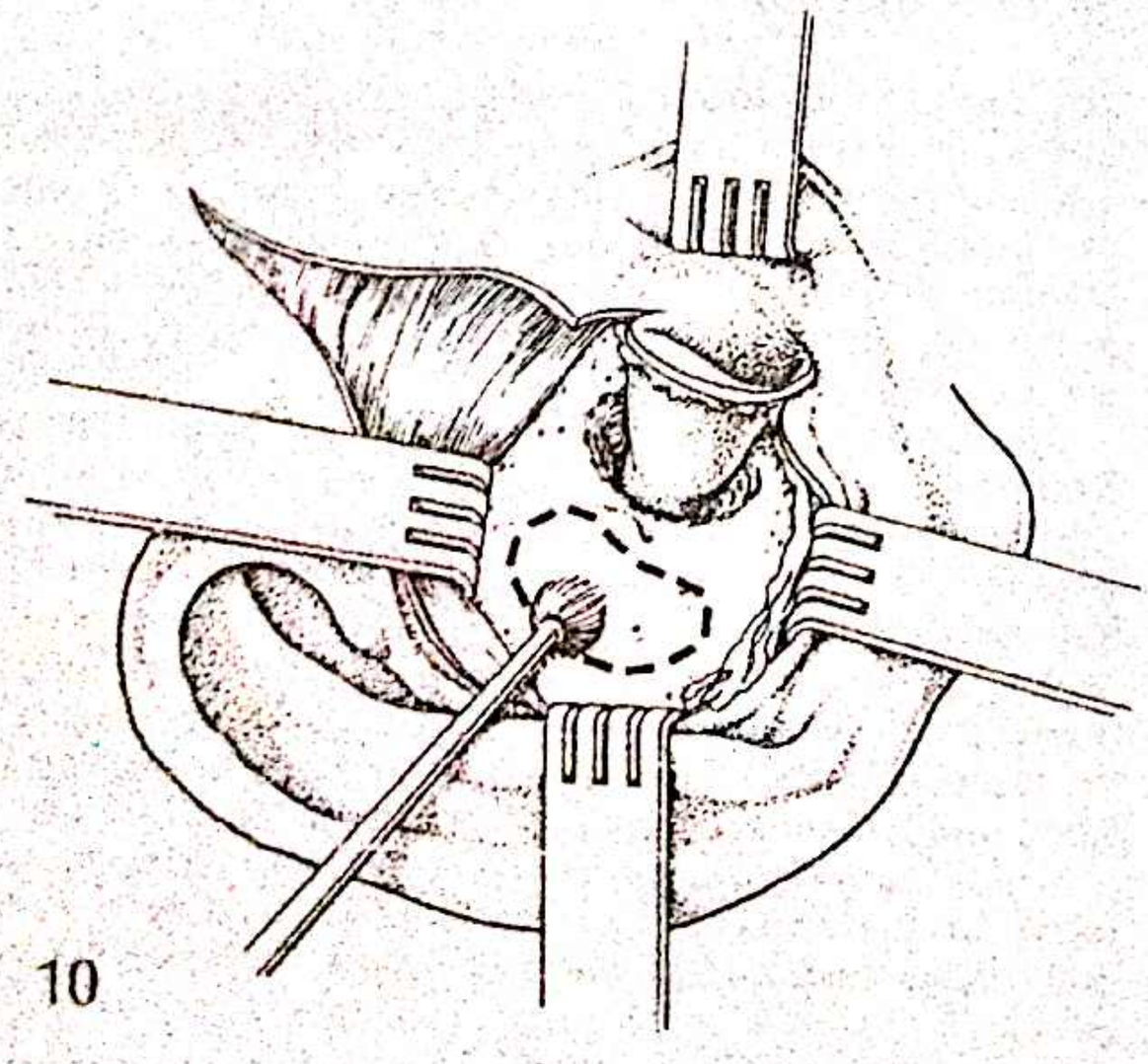


9

9

Exposure of mastoid and temporalis fascia

The lower meatal part of the incision is deepened through the periosteum until the meatal bone is felt, and the periosteum is separated from the underlying bone, upwards and backwards, with a periosteal elevator. This exposes the suprameatal spine, the suprameatal triangle and the bony cortex of the mastoid process from antero posteriorly. Self-retaining retractors, usually two at right angles, provide a good view of the operative field.



10

10

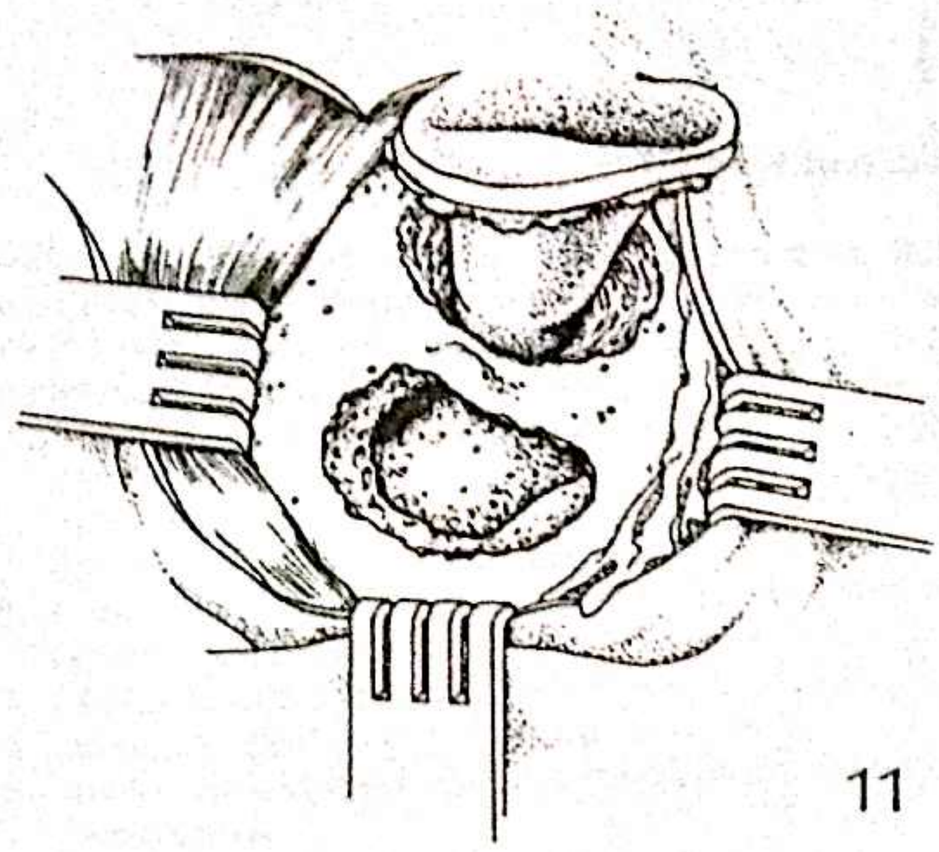
Reflection of meatal skin

The temporalis muscle is retracted upwards with a second retractor and mobilization of the meatal skin is commenced posteriorly, where it is reflected from the underlying bone down to the tympanic ring. Superiorly the thicker canal skin is reflected downwards and the dissection carried forwards. Especial care must be exercised in separating the skin from the anterosuperior (squamotympanic) and posterior (tympanomastoid) sutures as the meatal flap is rolled downwards and forwards to expose the epitympanum. In acquired meatal atresia it may be necessary to excise part of the thickened subcutaneous layer until healthy skin is reached.

11

Exposure of mastoid antrum

The antrum in adults is exposed by drilling through the overlying cortex with a cutting burr. Initial bone cuts are made with a 6 mm cutting burr, which is then replaced by smaller burrs to complete the excavation of bone. The direction of bone work should be downwards, forwards and medially. Continuous irrigation combined with suction is of great benefit.

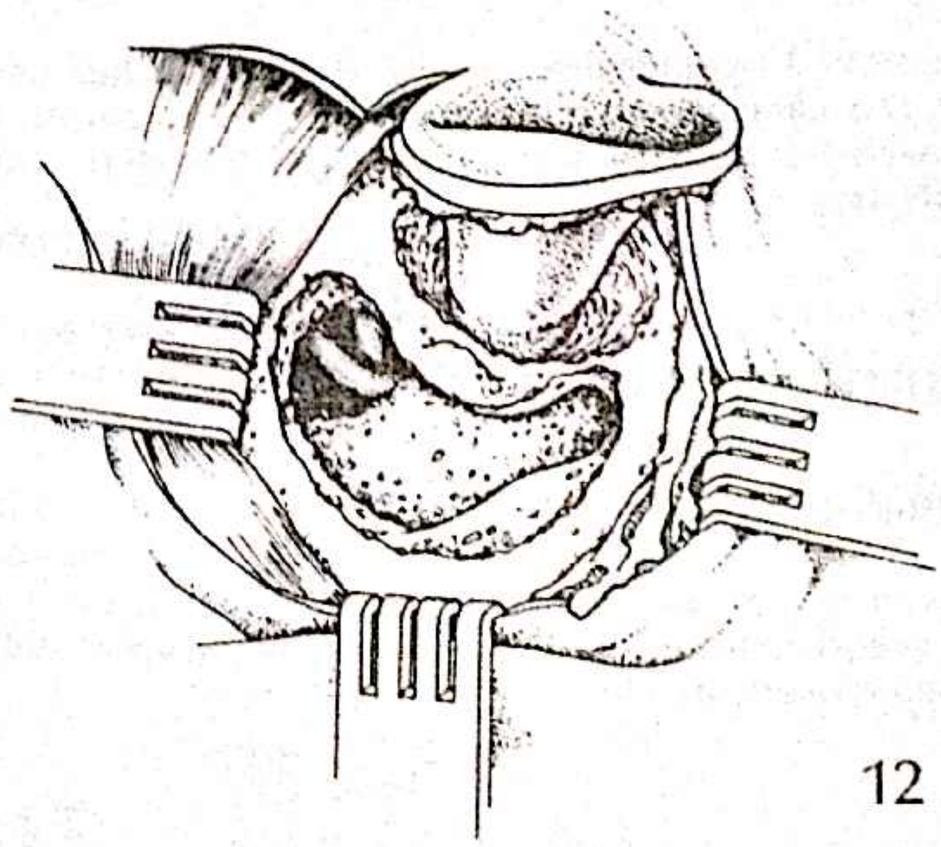


11

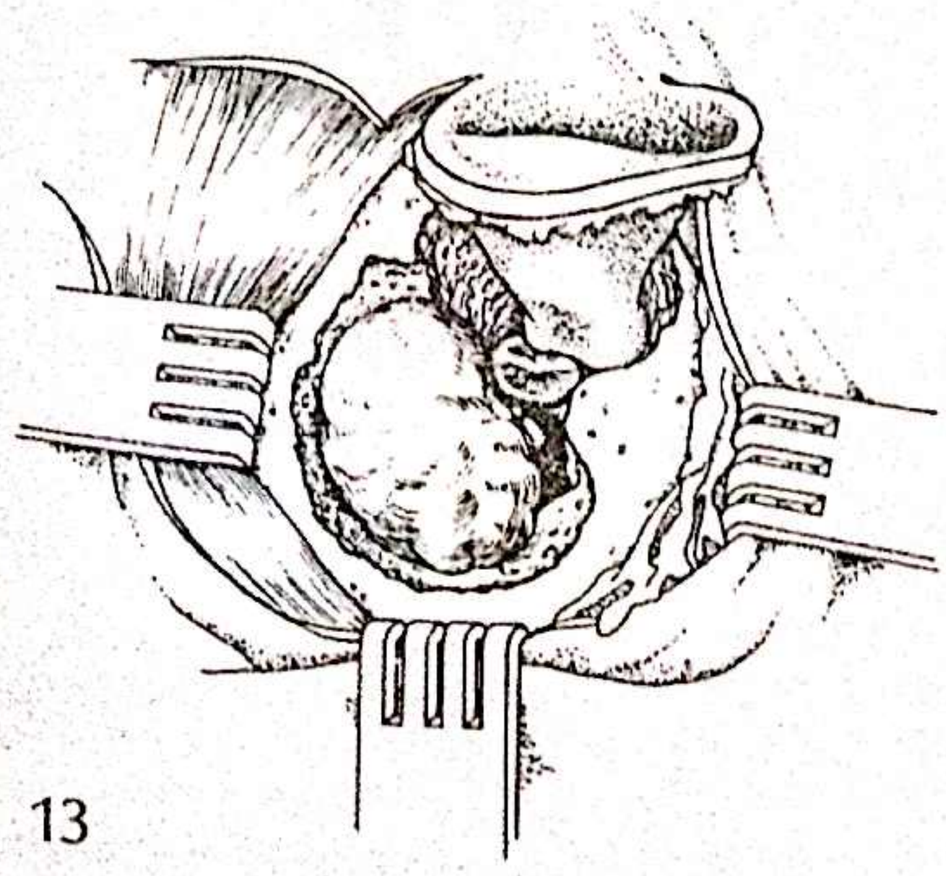
12

Exposure of attic and mastoid bowl

The attic is exposed by drilling forwards from the antrum into the root of the zygoma. The short process of the incus is identified in the fossa incudis, which is situated inferiorly at the aditus to the antrum. The malleoincudal joint is identified in the epitympanum. Removal of the incus exposes the horizontal semicircular canal, which lies medially and slightly posteriorly to the short process of the incus. The horizontal portion of the facial canal lies below the anterior end of the horizontal semicircular canal and medially to the incus. Further drilling of the mastoid posteriorly exposes the sinodural angle, sigmoid sinus and the tip cells from above downwards.



12



13

13

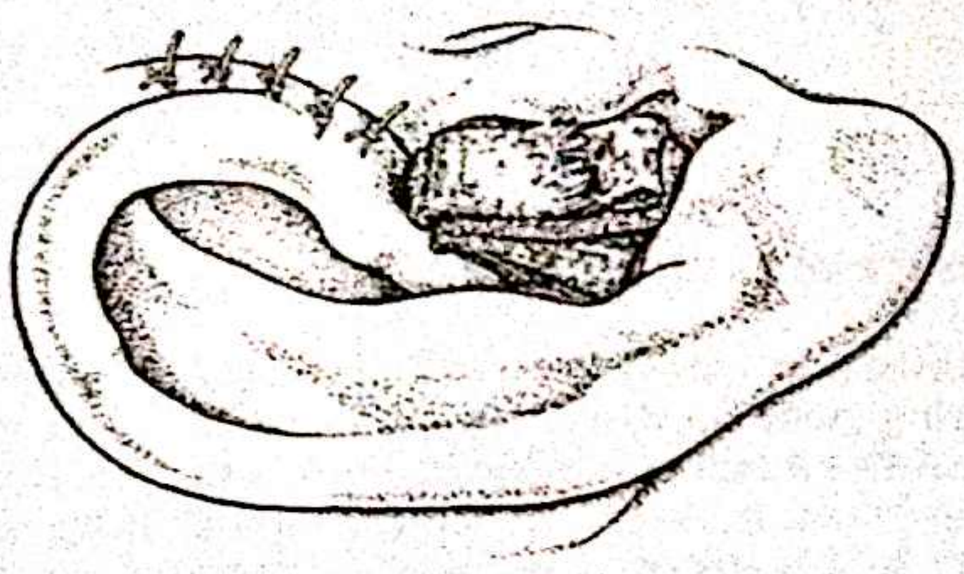
Atticotomy and attico-antrostomy

Starting superoposteriorly, the canal skin is mobilized downwards and forwards to expose the posterior part of the middle ear and the eroded outer attic wall. If the incudostapedial joint is intact, it is essential to disconnect the joint and displace the incus before starting drilling. The outer attic wall is first reduced with a bone curette to allow the introduction of a small cutting burr. Drilling is then continued with progressively larger burrs until the entire attic is exposed. If the bone work is extended posterosuperiorly the antrum will be exposed. At all times the direction of bone cuts must be from within outwards.

14

Closure of wound

A BIPP pack is commonly used in the external auditory canal. Interrupted deep 2/0 chromic catgut stitches are used to approximate the edges. The skin is closed with interrupted silk sutures. A firm mastoid bandage is applied, leaving the contralateral ear free from the edge of the bandage.



14

Postoperative care

If controlled hypotensive general anaesthesia has been used, the same precautions as outlined for the permeatal approach are taken. Pack and stitches are removed on the eighth day.

Complications

Immediate complications

1. *Facial nerve paralysis.* Facial nerve function must be checked on the operated side while the patient is still in the recovery area.
2. *Perichondritis* is often due to Gram-negative organisms and anaerobic bacteroides, both of which are found in abundance in infected cholesteatoma. A suitable antibiotic cover is helpful.
3. *Vertigo and 'dead ear'* are usually due to a combination of disease and surgery.

Delayed complications

Meatal stenosis could be avoided by care in closure of the wound and an appropriate pack.

POSTAURAL APPROACH

Preoperative

Indications

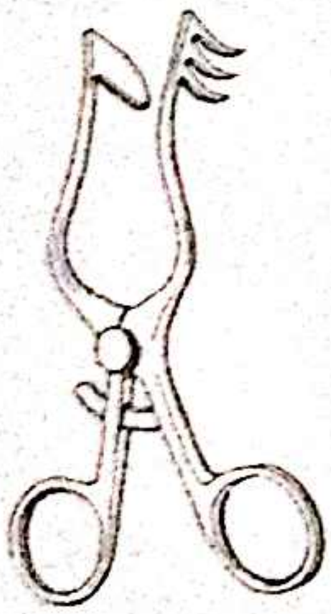
The increasing popularity of the postaural approach is perhaps due to developments in the techniques of intact canal wall tympanoplasty and more recently the translabyrinthine approach to the internal auditory canal. The postaural approach offers excellent exposure of the entire mastoid bowl and epitympanum, and allows access into the posterior fossa. It has the added advantage of allowing dissection in the anterior recess of the deep meatus even in the presence of a canal hump. The common indications are:

1. simple mastoidectomy and drainage of subperiosteal abscess in acute coalescent mastoiditis not responding to antibiotics or, occasionally, simple mastoidectomy for resistant secretory otitis;
2. modified radical and radical mastoidectomy for chronic suppurative otitis media with or without cholesteatoma;
3. combined approach intact canal wall tympanoplasty with or without posterior tympanotomy;
4. homograft drum reconstruction;
5. in Menière's disease, exposure of the saccus endolymphaticus, membranous or ultrasonic labyrinthectomy, or translabyrinthine division of the vestibular nerve in the presence of severe sensorineural hearing loss;
6. facial nerve surgery, e.g. decompression of the descending portion or reconstruction of the nerve in traumatic palsy;
7. translabyrinthine removal of acoustic tumours confined to the porus acusticus;
8. retrolabyrinthine approach to the cranial nerves in the cerebellopontine angle;
9. carcinoma of the middle ear cavity;
10. extensive glomus jugulare tumours;
11. rarely, thrombophlebitis arising from lateral sinus thrombosis;
12. some cases of congenital atresia.

Investigations

In surgery of the internal auditory meatus and cerebellopontine angle, sophisticated radiological investigations are required.

General investigations, preparation of the ear, anaesthesia and position of the patient are as for the endaural approach.



15

Instrumentation

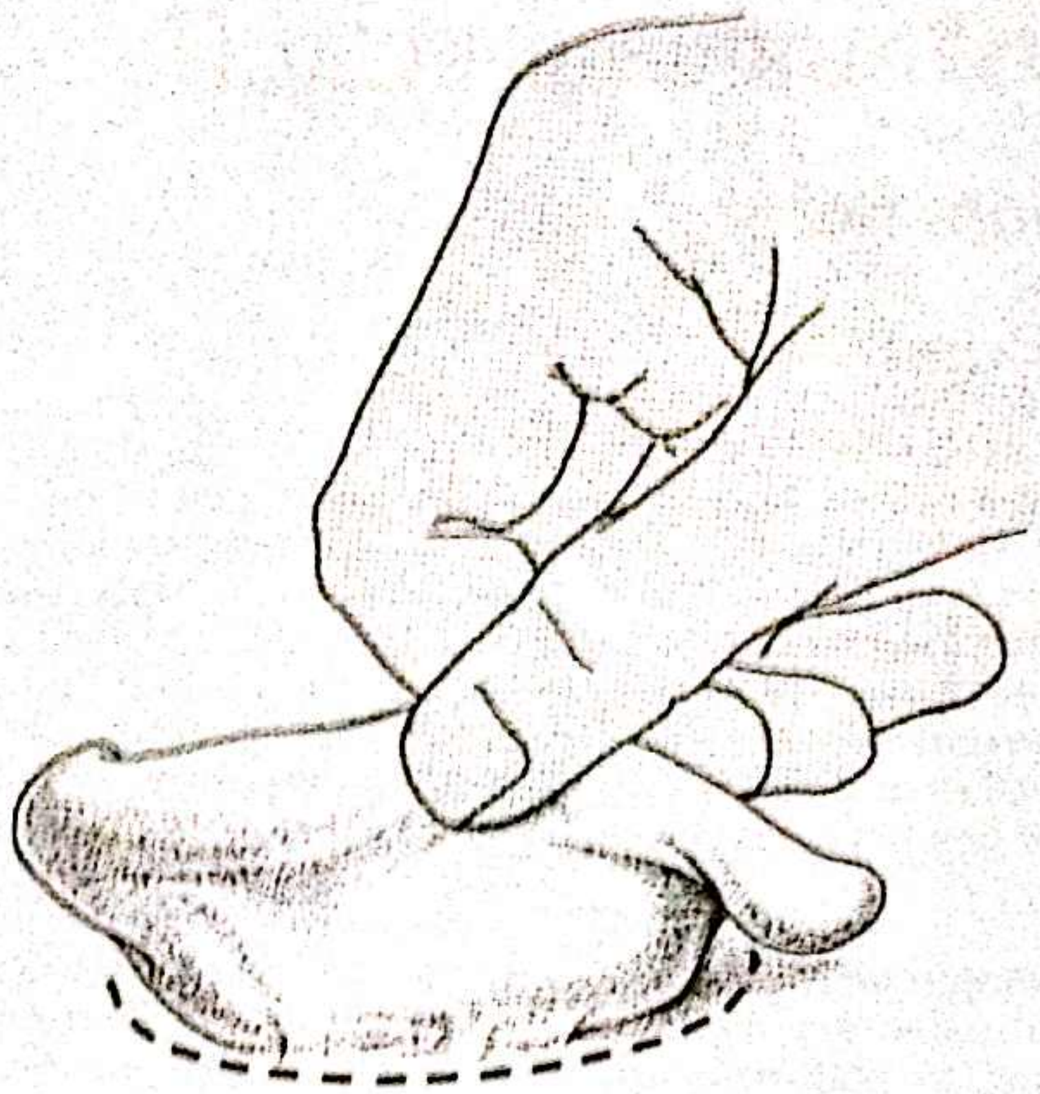
In addition to the instruments needed for the endaural approach, special instruments would be required for surgery on the endolymphatic sac, for ultrasonic destruction of the membranous labyrinth, and for the translabyrinthine approaches to the internal auditory meatus. A Plester-Jansen retractor is useful to retract the posterior canal wall skin forwards.

The approach

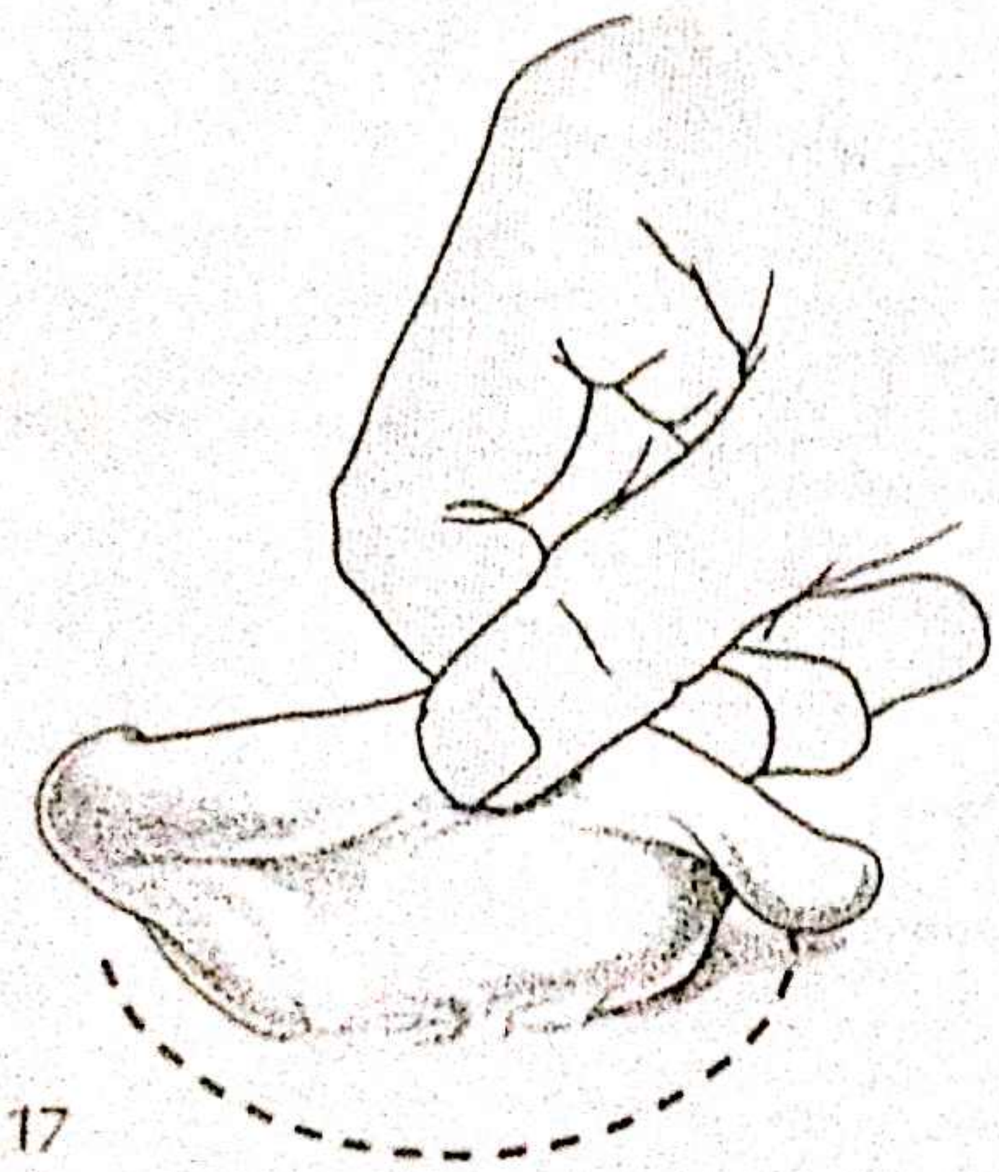
The incision

16

Gentle forward traction is applied to the pinna by the assistant. A curved incision is made in the natural postaural sulcus, starting at the 12 o'clock position superiorly and terminating at the 6 o'clock position just behind the ear lobule. The subcutaneous tissue and muscles of the auricle are divided with a diathermy needle using a cutting current. Haemostasis is achieved by progressively increasing the tension of the wound with a self-retaining retractor. The stretched posterior canal skin is identified.



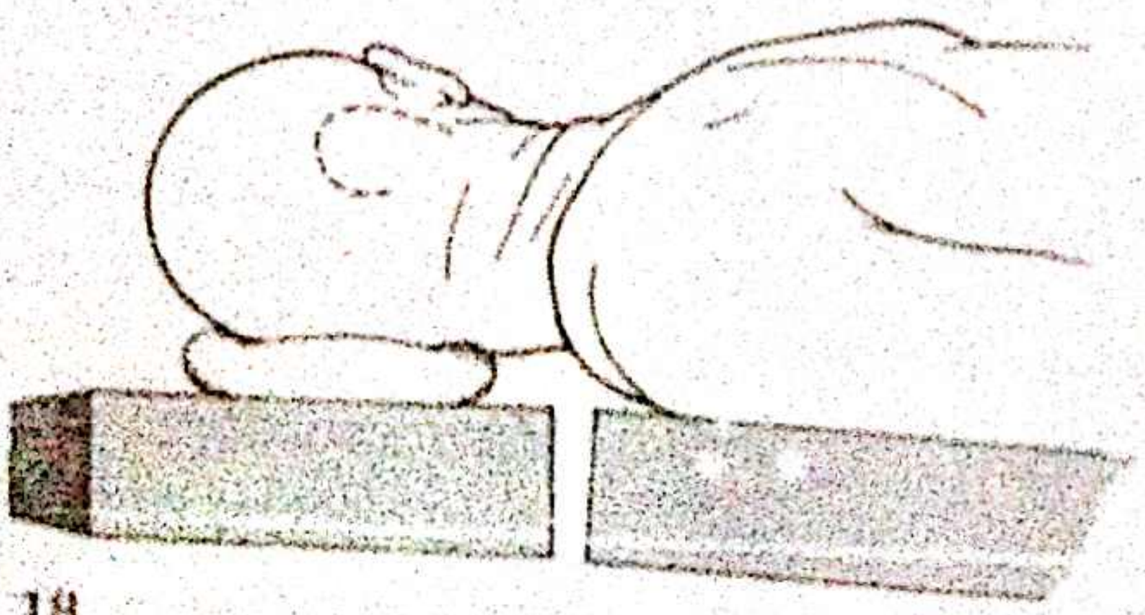
16



17

17

For surgical procedures involving extensive exenteration of the mastoid bowl, such as saccus decompression in a cellular mastoid, or a translabyrinthine or retrolabyrinthine approach to the petrous apex, a much more curved incision is preferred, about 1.5 to 2 cm posterior to the natural crease.



18

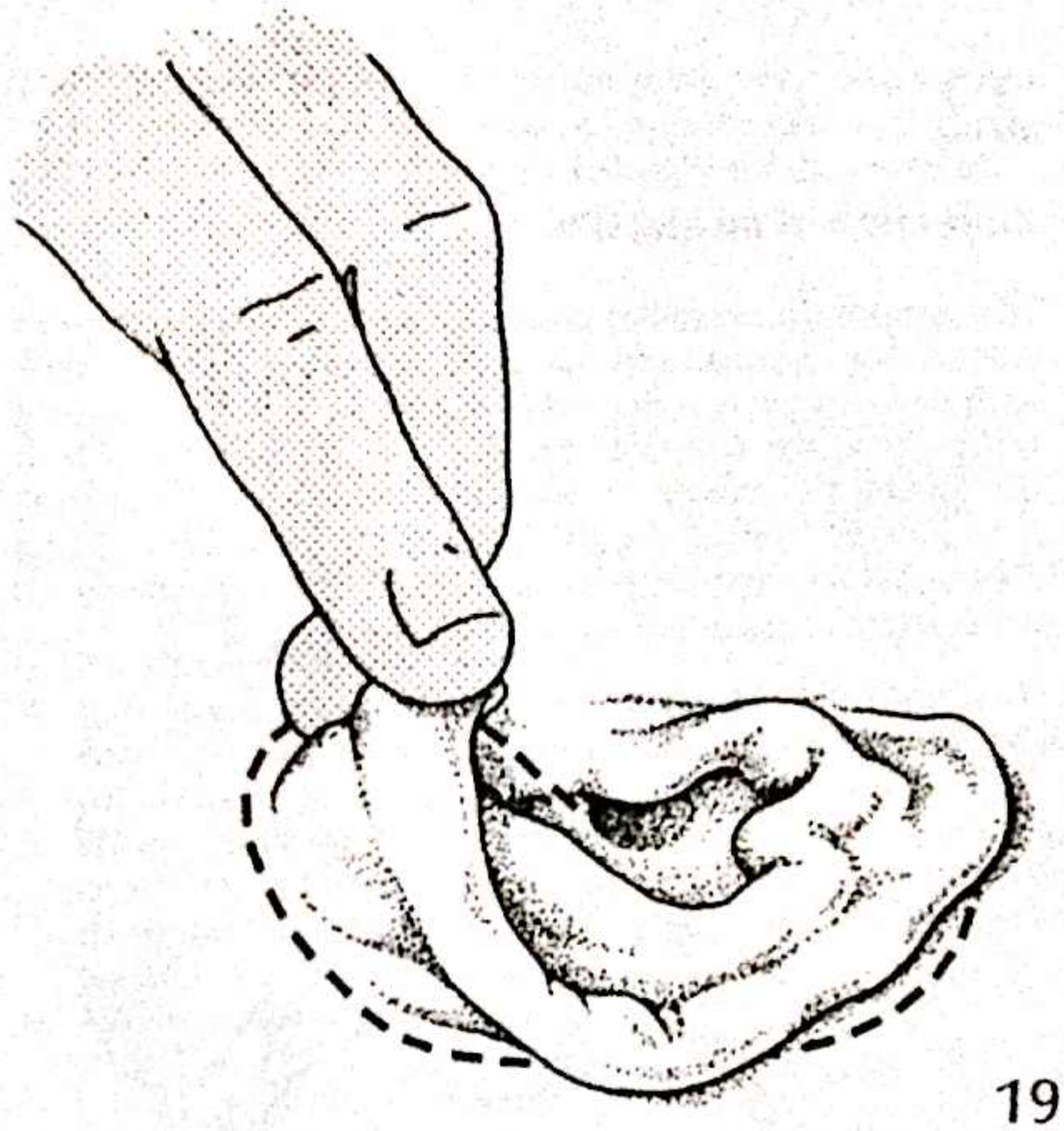
18

A wide U-shaped incision is preferred for the suboccipital approach to the cerebellopontine angle and internal auditory meatus.

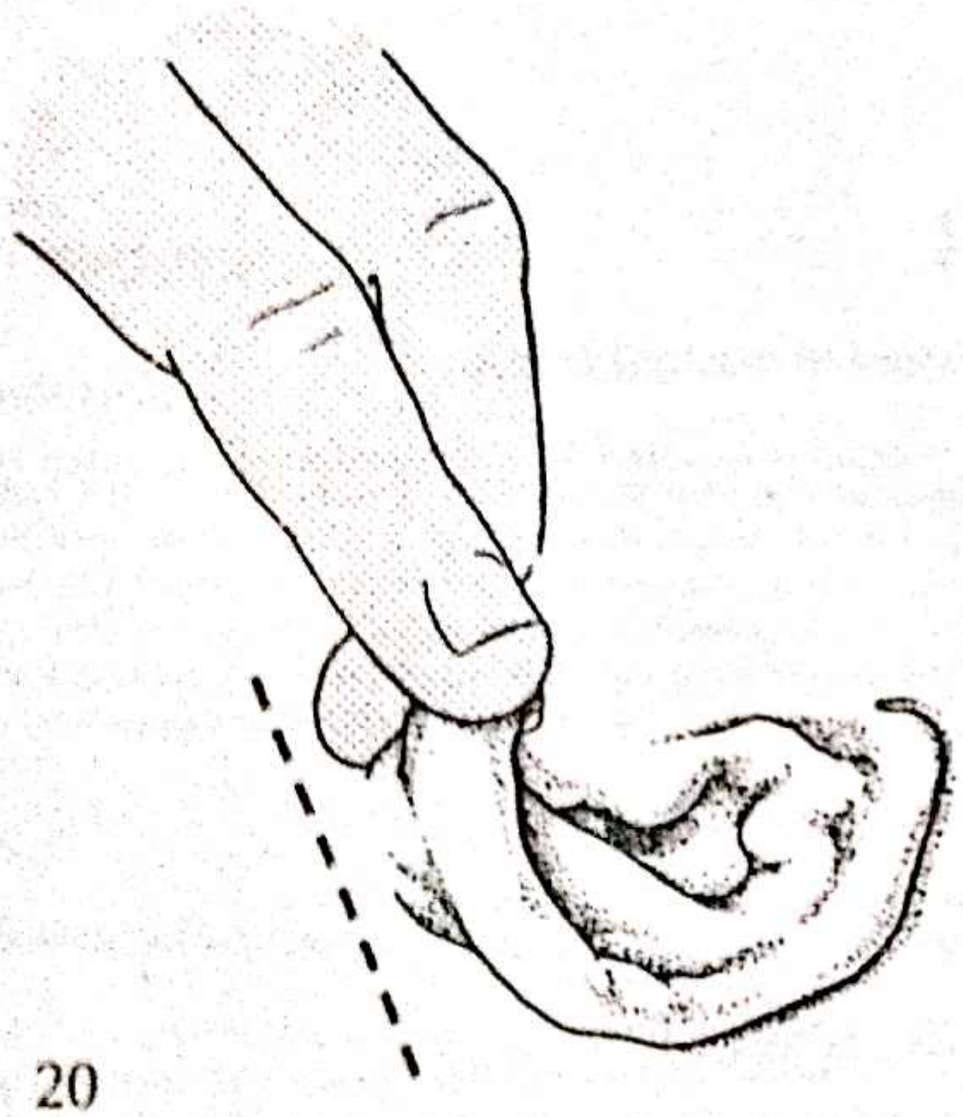
19

Combined endaural–postaural approach

An endaural incision can be extended into a postaural incision if there is extreme difficulty in drilling the region of the mastoid tip. Conversely, if exploration of the middle ear through a postauricular incision proves difficult, there is no contraindication to extending the upper end of the incision and converting it into an endaural incision.



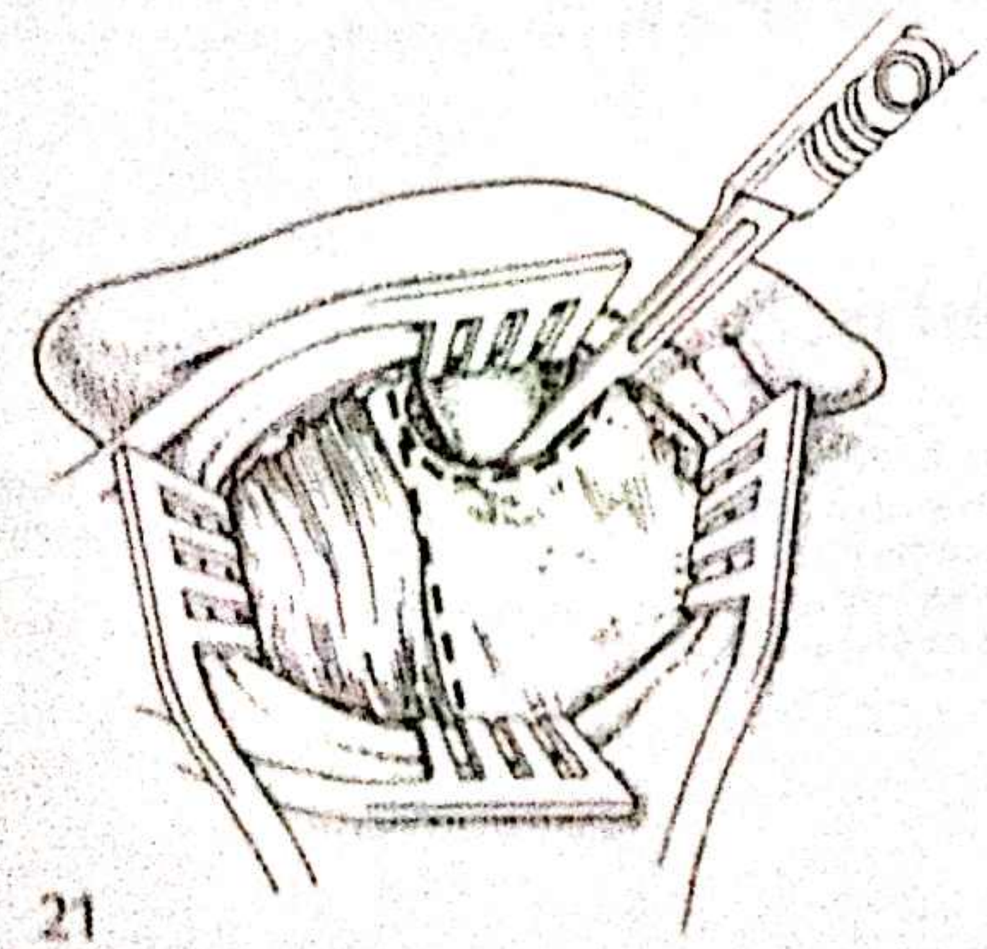
19



20

20

In infants and young children the mastoid antrum is much further forward than in adults, and lies above as well as behind the external auditory canal. The incision is therefore much more horizontal.



21

21

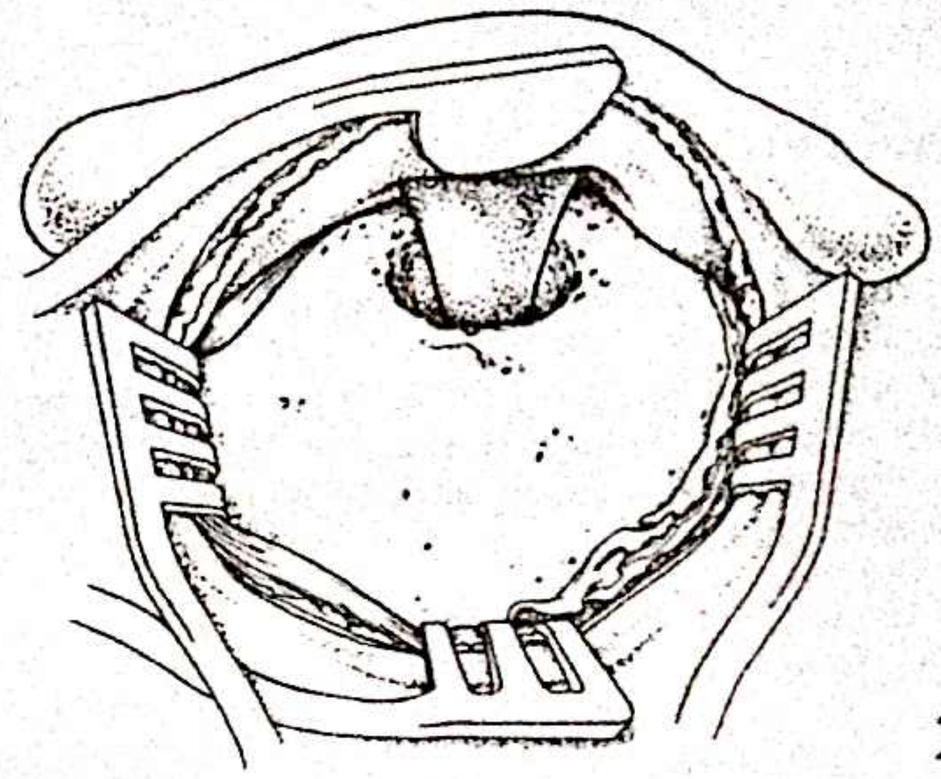
Reflection of periosteum

The overlying periosteum is divided by a T-shaped incision: the vertical limb is curved and runs parallel to the posterior meatal opening while the horizontal limb follows the supramastoid crest. The flaps of periosteum are widely separated to expose the entire mastoid cortex, suprameatal triangle and spine, and the bony posterior meatal margin from behind forwards. In a posteriorly placed postauricular incision (*see Illustrations 17 and 18*), the periosteum is divided along the line of the incision to provide better access to the mastoid bowl and suboccipital region.

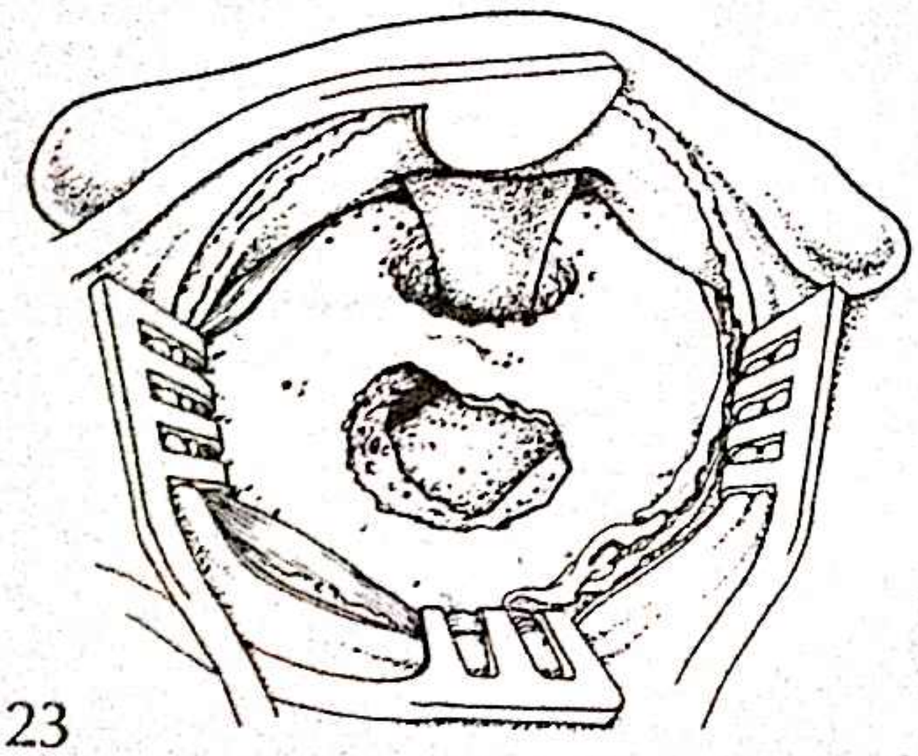
22

Reflection of meatal flap

The temporalis muscle is displaced upwards to expose the rest of the zygoma, and the posterior canal skin together with periosteum is reflected forwards from the underlying bone up to the tympanic margin. Similar mobilization of the meatal skin can be carried out superiorly and inferiorly if required. The self-retaining retractor is removed and a Plester-Jansen self-retaining retractor (*see Illustration 15*) is inserted to hold the meatal flap forward.



22

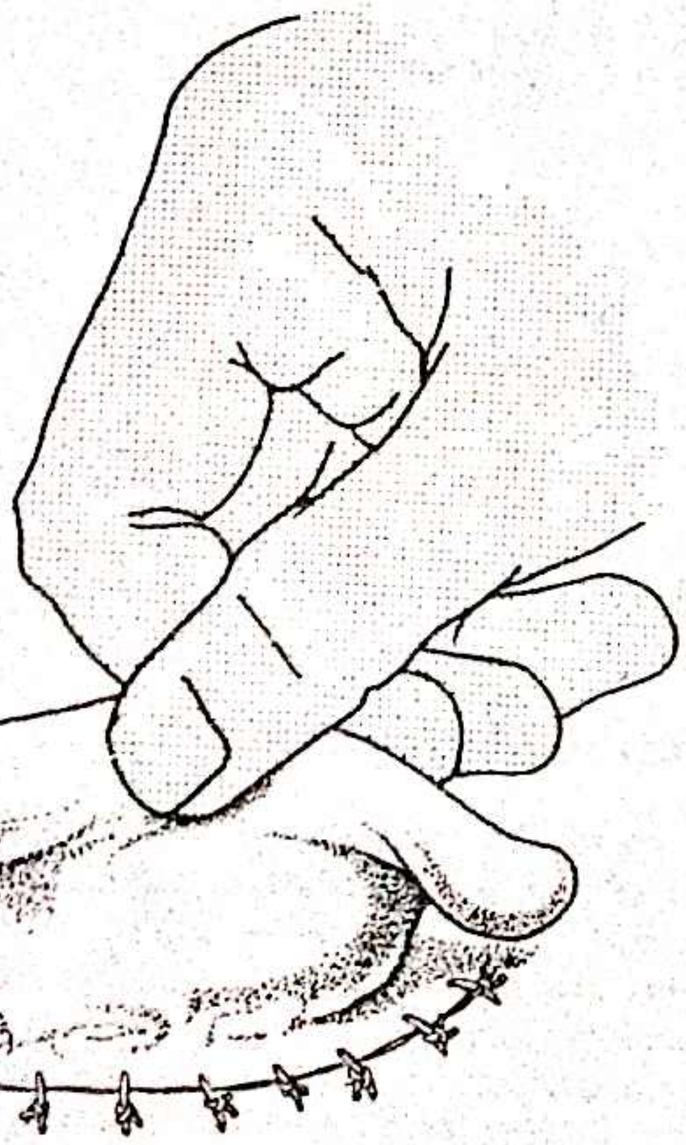


23

23

Exposure of mastoid antrum

The mastoid is exposed as in the endaural approach (*see Illustration 11*).



24

24

Closure of wound

At the end of the definitive procedure, the periosteal edges are approximated with interrupted catgut stitches. The skin is closed with interrupted silk sutures. A firm mastoid bandage is applied.

Postoperative care

This is the same as for the endaural approach. Neurological observation may be required after certain surgical procedures.

This approach may lead to the same complications as the endaural approach.

POSTERIOR TYMPANOTOMY FOR ACCESS TO THE FACIAL RECESS AND SINUS TYMPANI

In this procedure the posterior part of the mesotympanum, i.e. the facial recess and sinus tympani, is approached in a posteroanterior direction, working forward from the retroauricular area behind the meatal opening.

Preoperative

Indications

Posterior tympanotomy is the procedure of choice in the majority of patients with cholesteatoma involving the mastoid bowl, attic and mesotympanum, and in generalized and irreversible active mucosal disease of the mastoid bowl and tympanic cleft. In both cases the procedure may be combined with intact canal wall tympanoplasty.

Contraindications

The procedure should not be carried out in patients who are unable to report for long-term follow-up. Other contraindications are: a small sclerotic mastoid with a forwardly placed sigmoid sinus; malignant disease; intracranial complications of chronic suppurative otitis media; labyrinthine fistula in an only hearing ear; an intact ossicular chain – disconnection of the incudostapedial joint is mandatory before commencing the bone work. It is essential that the operator is experienced and careful practice on temporal bones is strongly recommended.

Advantages

1. When combined with tympanoplasty, the canal wall is preserved together with the annulus, which helps to reconstruct the new ear drum in its normal position.
2. Preservation of the normal dimensions of the middle ear cavity.
3. Aeration of the mastoid cavity.
4. Avoidance of an open cavity with its inherent shortcomings for sound signals. An open cavity also predisposes to a caloric effect in swimmers.
5. When combined with tympanoplasty, the ossicular chain can be checked for accurate realignment through the posterior tympanotomy after the ear canal has been packed over a graft.
6. Avoids a cavity in children.

Disadvantages

The greatest disadvantage is the inevitable blind spot in the tympanic recess and posterior hypotympanum where residual disease may remain unnoticed. The operation takes longer than a radical mastoidectomy and the rate of recurrence of cholesteatoma seems to increase with increasing length of postoperative follow-up and in some centres is unacceptably high.

Investigations, preparation of the ear, anaesthesia and position of the patient are as for the endaural approach.

Instrumentation

In addition to the instruments needed for the endaural approach, a full range of diamond, cutting and polishing burrs is required. Continuous suction and irrigation is essential.

POSTERIOR TYMPANOTOMY FOR ACCESS TO THE FACIAL RECESS AND SINUS TYMPANI

In this procedure the posterior part of the mesotympanum, i.e. the facial recess and sinus tympani, is approached in a posteroanterior direction, working forward from the retroauricular area behind the meatal opening.

Preoperative

Indications

Posterior tympanotomy is the procedure of choice in the majority of patients with chclesteatoma involving the mastoid bowl, attic and mesotympanum, and in generalized and irreversible active mucosal disease of the mastoid bowl and tympanic cleft. In both cases the procedure may be combined with intact canal wall tympanoplasty.

Contraindications

The procedure should not be carried out in patients who are unable to report for long-term follow-up. Other contraindications are: a small sclerotic mastoid with a forwardly placed sigmoid sinus; malignant disease; intracranial complications of chronic suppurative otitis media; labyrinthine fistula in an only hearing ear; an intact ossicular chain – disconnection of the incudostapedial joint is mandatory before commencing the bone work. It is essential that the operator is experienced and careful practice on temporal bones is strongly recommended.

Advantages

1. When combined with tympanoplasty, the canal wall is preserved together with the annulus, which helps to reconstruct the new ear drum in its normal position.
2. Preservation of the normal dimensions of the middle ear cavity.
3. Aeration of the mastoid cavity.
4. Avoidance of an open cavity with its inherent shortcomings for sound signals. An open cavity also predisposes to a caloric effect in swimmers.
5. When combined with tympanoplasty, the ossicular chain can be checked for accurate realignment through the posterior tympanotomy after the ear canal has been packed over a graft.
6. Avoids a cavity in children.

Disadvantages

The greatest disadvantage is the inevitable blind spot in the tympanic recess and posterior hypotympanum where residual disease may remain unnoticed. The operation takes longer than a radical mastoidectomy and the rate of recurrence of cholesteatoma seems to increase with increasing length of postoperative follow-up and in some centres is unacceptably high.

Investigations, preparation of the ear, anaesthesia and position of the patient are as for the endaural approach.

Instrumentation

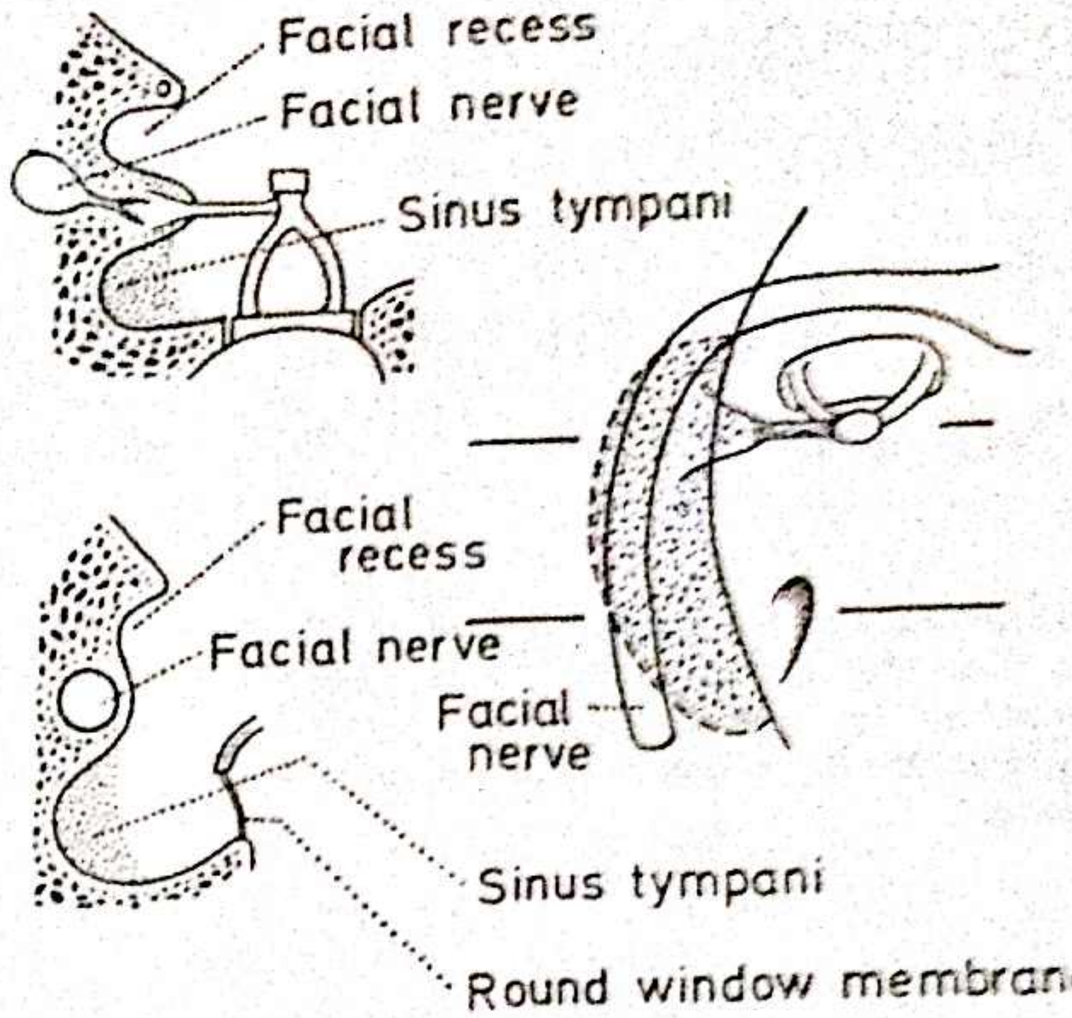
In addition to the instruments needed for the endaural approach, a full range of diamond, cutting and polishing burrs is required. Continuous suction and irrigation is essential.

Surgical anatomy

25

The sinus tympani is divided by the facial canal into the facial recess laterally and the tympanic recess medially. The key to the success of posterior tympanotomy rests in uncovering the facial recess from behind so that a direct view of the posterior mesotympanum is obtained.

An excellent account of the surgical anatomy of the sinus tympani, including normal variations, has been published by Donaldson *et al*[1].

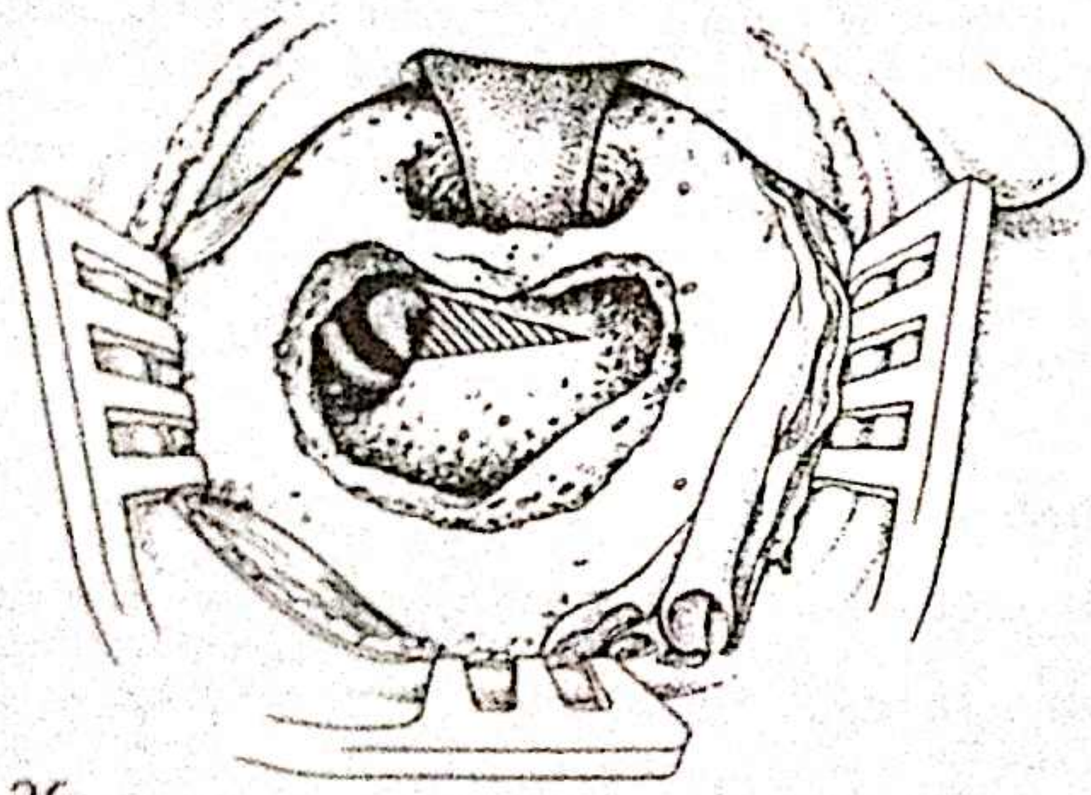


25

Antrum threshold angle

26

The surgical landmark for opening the facial recess from behind is a triangular area of bone called the antrum threshold angle, which is formed above by the horizontal semicircular canal and fossa incudis; medially by the descending portion of the facial nerve; and laterally by the chorda tympani. Once the facial recess has been adequately opened through this triangular area the pyramidal process becomes clearly visible.



26

Ponticulus and subiculum

The posterior part of the medial wall of the tympanic cavity is divided into three depressions by two bony ridges called the ponticulus and the subiculum. The groove above the ponticulus is the oval window region, the groove below the subiculum is the round window region, and the space between the two ridges is the tympanic recess. The ponticulus pyramidalis[2] is a ridge of bone which runs laterally from the pyramidal process to the chorda tympani aperture.

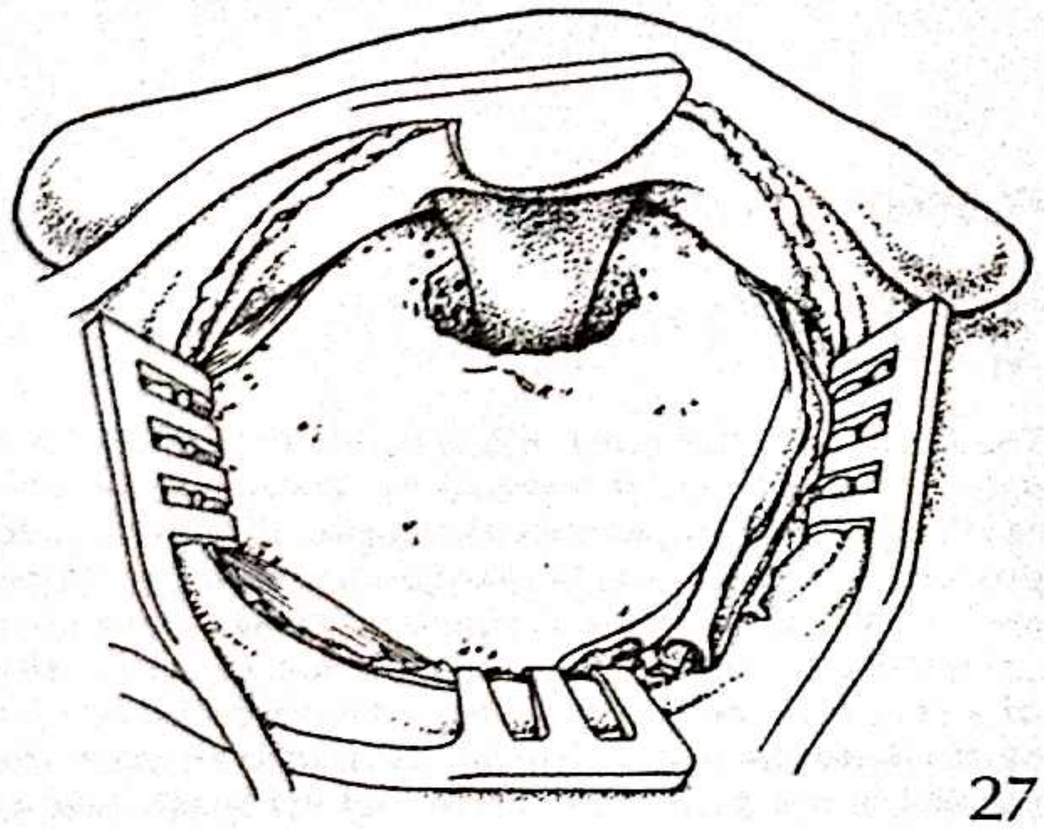
The approach

The incision and reflection of periosteum are as for the postaural approach (*see Illustrations 16–21*).

27

Reflection of meatal flap

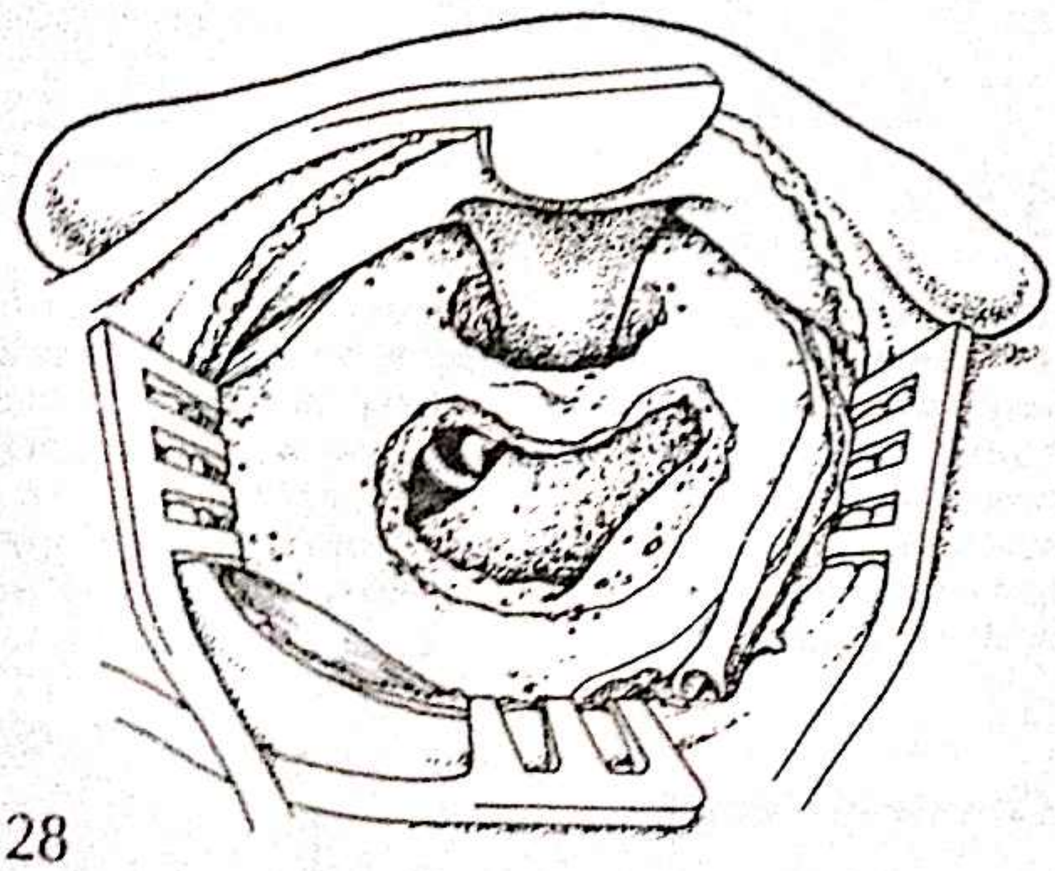
The posterior canal skin is reflected forwards from the underlying bone. The extent of middle ear disease is determined by reflecting the tympanic membrane from the sulcus. However, in the presence of an attic or posterior marginal perforation, the meatal flap is reflected forwards after mobilizing it posteriorly and superiorly. The state of the incudostapedial joint is determined.



27

Exposure of mastoid antrum

The mastoid antrum is exposed as in the endaural and postaural approaches (*see Illustrations 11 and 23*).



28

Completion of mastoidectomy and exposure of epitympanum

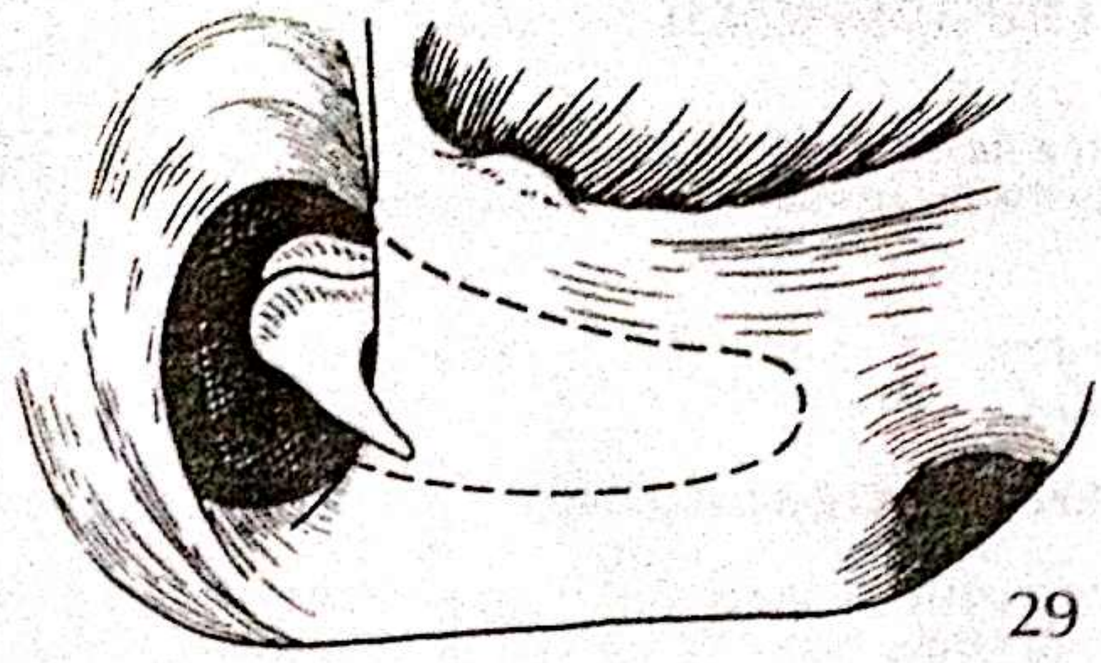
28

The entire mastoid bowl is exenterated from the tip of the mastoid process below to the thin tegmen tympani above; and from the sinus plate behind the posterior bony canal into the root of the zygoma to expose the epitympanum, taking care to preserve the outer attic wall. The short process of the incus and the malleo-incudal joint are exposed. If the incus is missing, the horizontal semi-circular canal is identified.

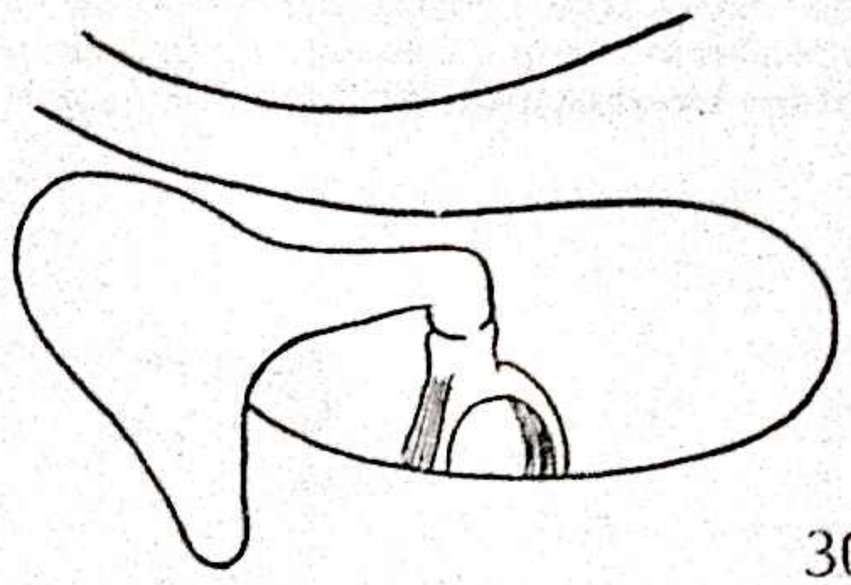
Posterior tympanotomy

29 & 30

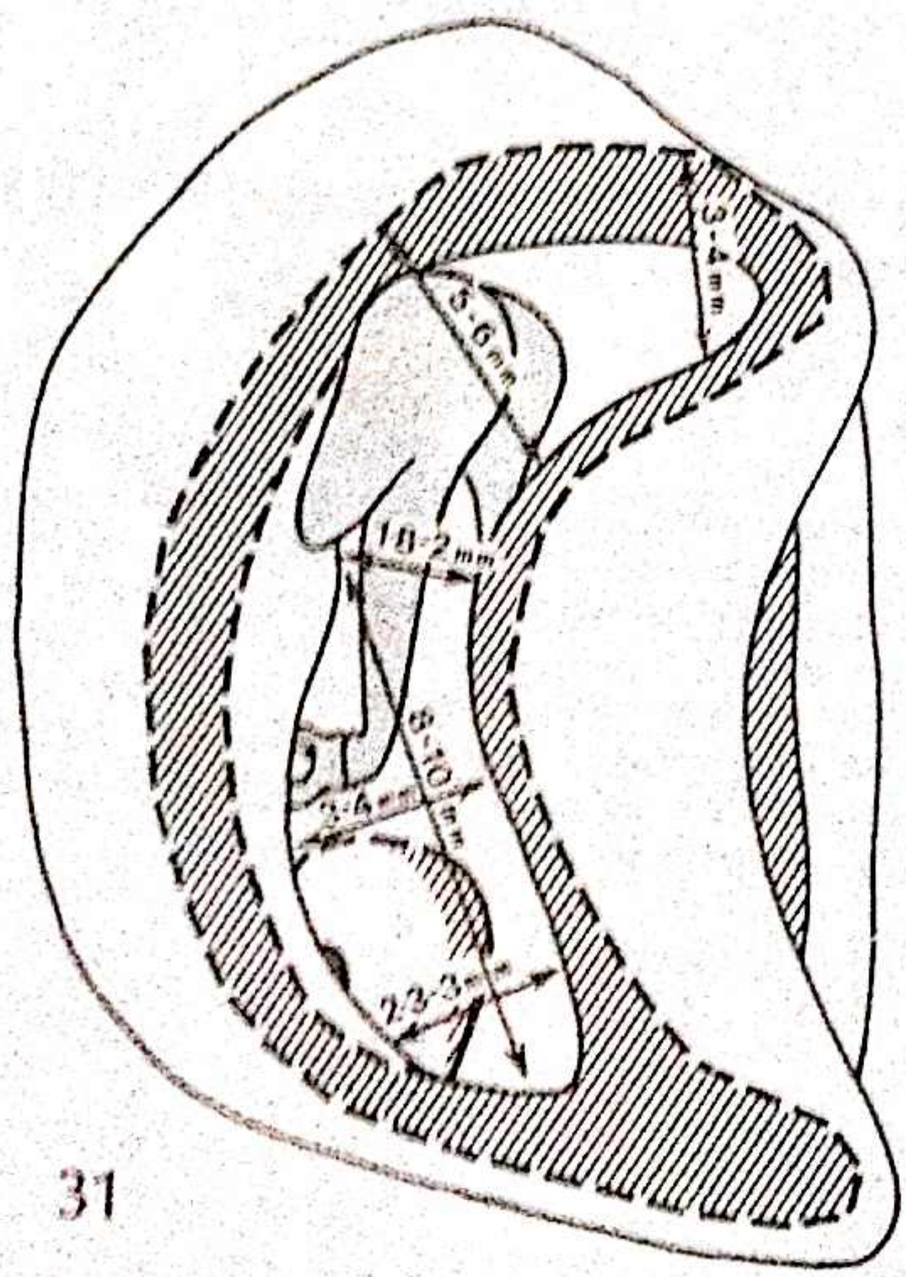
The bony posterior canal wall is carefully thinned down, and the facial recess is exposed by saucerizing the bone overlying the antrum threshold angle. This stage of the procedure is best carried out with a 2.5 mm diamond burr and continuous suction-irrigation. Initial bone work commences superiorly immediately lateral to the short process of the incus and is directed towards the tip of the mastoid process below. The bony dissection is maintained parallel to the descending portion of the facial nerve and is deepened medially and forwards towards the facial recess. The posterior tympanotomy finally assumes a bean-shaped opening, and further exposure is obtained by carefully drilling the pyramidal process, ponticulus pyramidalis and subiculum.



29



30



31

31

The dimensions of the posterior tympanotomy were first recorded by Banfai from 30 temporal bone dissections and have subsequently been quoted by Jako[3]. The distance from the fossa incudis above to the hypotympanum below varies from 8 to 10 mm and the width midway between the oval window above and the round window below from 3 to 4 mm. The width at the level of fossa incudis is between 0.18 and 2 mm.

Closure of wound

Usually a BIPP pack is inserted in the external auditory canal. Skin closure and mastoid bandage are as for the postural approach.

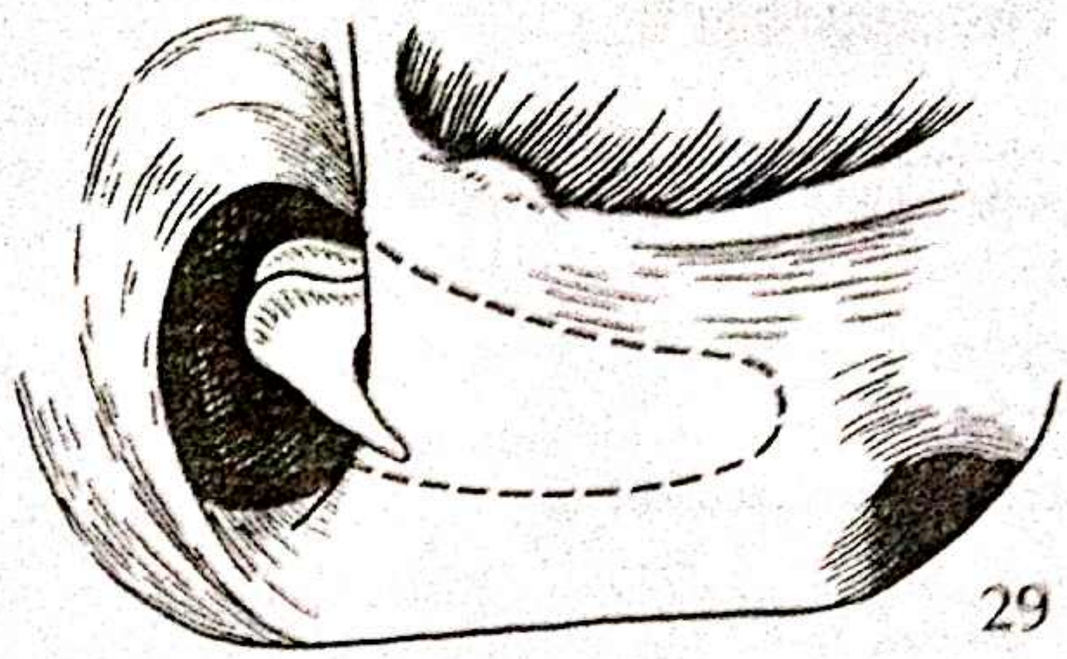
Postoperative care

It is essential to check the function of the facial nerve before the patient leaves the recovery room. Otherwise postoperative care is as for the endaural approach.

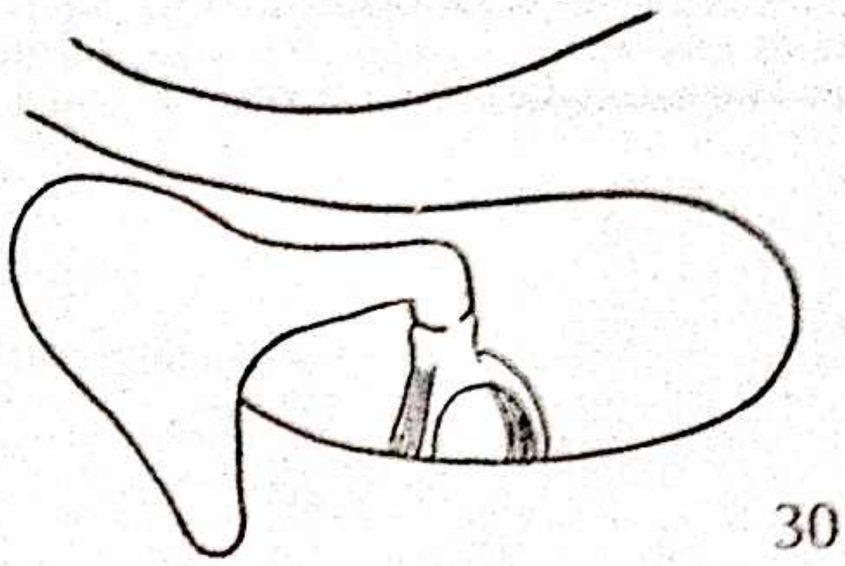
Posterior tympanotomy

29 & 30

The bony posterior canal wall is carefully thinned down, and the facial recess is exposed by saucerizing the bone overlying the antrum threshold angle. This stage of the procedure is best carried out with a 2.5 mm diamond burr and continuous suction-irrigation. Initial bone work commences superiorly immediately lateral to the short process of the incus and is directed towards the tip of the mastoid process below. The bony dissection is maintained parallel to the descending portion of the facial nerve and is deepened medially and forwards towards the facial recess. The posterior tympanotomy finally assumes a bean-shaped opening, and further exposure is obtained by carefully drilling the pyramidal process, ponticulus pyramidalis and subiculum.



29



30

31

31

The dimensions of the posterior tympanotomy were first recorded by Banfai from 30 temporal bone dissections and have subsequently been quoted by Jako[3]. The distance from the fossa incudis above to the hypotympanum below varies from 8 to 10 mm and the width midway between the oval window above and the round window below from 3 to 4 mm. The width at the level of fossa incudis is between 0.18 and 2 mm.

Closure of wound

Usually a BIPP pack is inserted in the external auditory canal. Skin closure and mastoid bandage are as for the postural approach.

Postoperative care

It is essential to check the function of the facial nerve before the patient leaves the recovery room. Otherwise postoperative care is as for the endaural approach.

CIRCUMFERENTIAL TYMPANOMASTOID ACCESS TO THE FACIAL RECESS AND SINUS TYMPANI

In this procedure[4] the facial recess and sinus tympani are approached in an anteroposterior direction, working from anterior to the meatal opening and looking directly through the meatus, into the sinus tympani. Thus a posteroanterior approach is used for access to the mastoid and epitympanum while an anteroposterior approach is used for access to the facial recess and sinus tympani – the combination of these two approaches providing a circumferential tympano-mastoid access through 270°.

Advantages

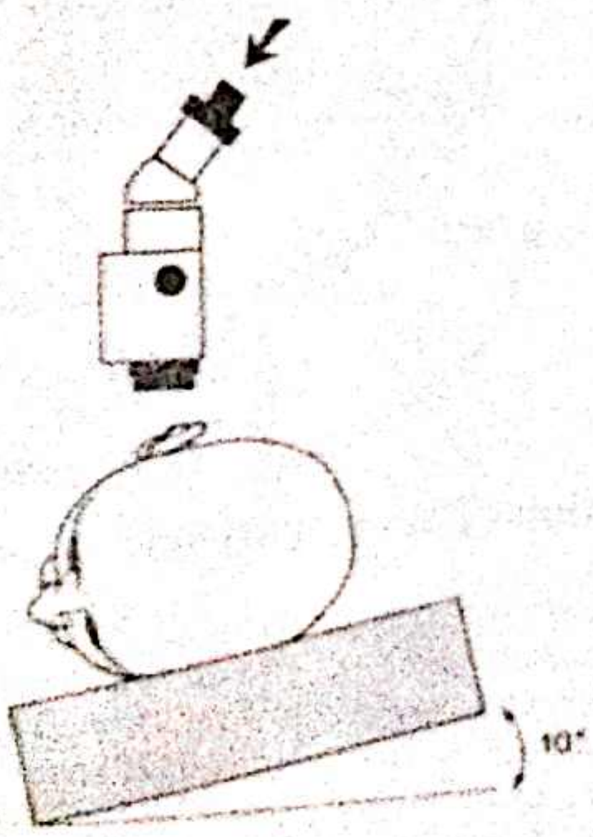
The main advantage is the ability to visualize extension of disease deep to the vertical portion of the facial nerve. Should the sinus tympani extend further inferiorly and posteriorly, the anteroposterior approach provides a better means of eradicating the disease completely. It is the procedure of choice in a small sclerotic mastoid with a forwardly placed sigmoid sinus, in which posterior tympanotomy may be hazardous. Finally, injury to the facial nerve is rare.

Preparation of the ear, general investigations and anaesthesia are as for the endaural approach.

An endaural incision is preferred.

Instrumentation

In addition to the instruments required for posterior tympanotomy, an angled viewing binocular tube for the Zeiss operating microscope is essential. An operating table with lateral tilting facilities is useful. In the absence of such a table, a large sorbo-rubber wedge as used in X-ray departments will suffice.



32

Position of patient and surgeon

32

To complete the mastoid dissection posteroanteriorly, the head is tilted 10° posteriorly. The surgeon is positioned behind the ear and the microscope stand in front of the head.

CIRCUMFERENTIAL TYMPANOMASTOID ACCESS TO THE FACIAL RECESS AND SINUS TYMPANI

In this procedure[4] the facial recess and sinus tympani are approached in an anteroposterior direction, working from anterior to the meatal opening and looking directly through the meatus, into the sinus tympani. Thus a posteroanterior approach is used for access to the mastoid and epitympanum while an anteroposterior approach is used for access to the facial recess and sinus tympani – the combination of these two approaches providing a circumferential tympano-mastoid access through 270°.

Advantages

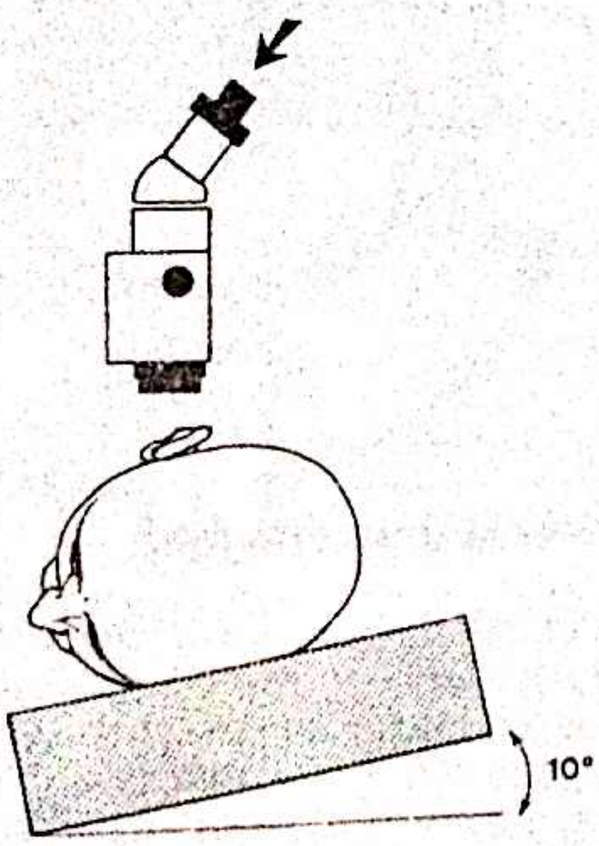
The main advantage is the ability to visualize extension of disease deep to the vertical portion of the facial nerve. Should the sinus tympani extend further inferiorly and posteriorly, the anteroposterior approach provides a better means of eradicating the disease completely. It is the procedure of choice in a small sclerotic mastoid with a forwardly placed sigmoid sinus, in which posterior tympanotomy may be hazardous. Finally, injury to the facial nerve is rare.

Preparation of the ear, general investigations and anaesthesia are as for the endaural approach.

An endaural incision is preferred.

Instrumentation

In addition to the instruments required for posterior tympanotomy, an angled viewing binocular tube for the Zeiss operating microscope is essential. An operating table with lateral tilting facilities is useful. In the absence of such a table, a large sorbo-rubber wedge as used in X-ray departments will suffice.



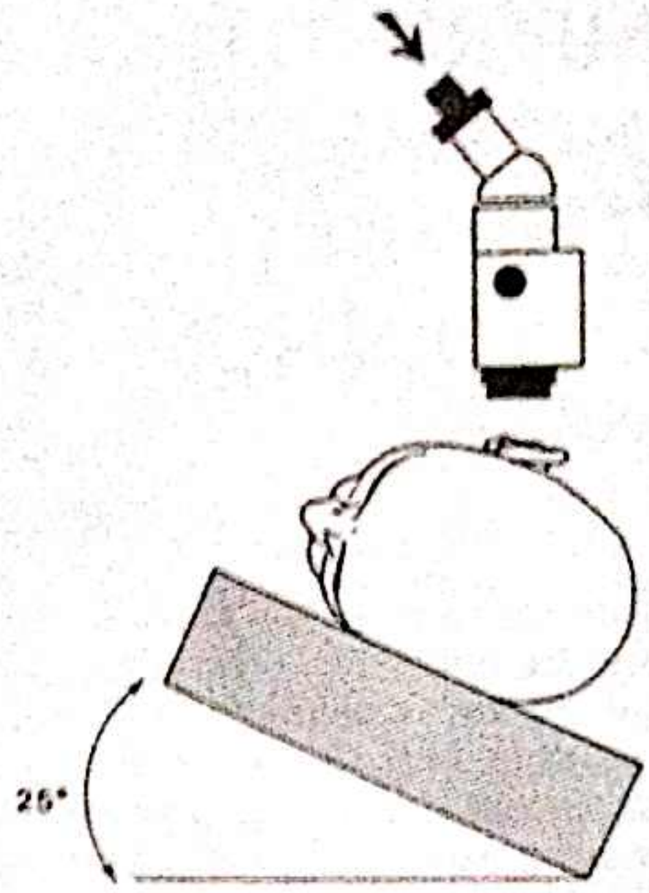
Position of patient and surgeon

32

To complete the mastoid dissection posteroanteriorly, the head is tilted 10° posteriorly. The surgeon is positioned behind the ear and the microscope stand in front of the head.

33

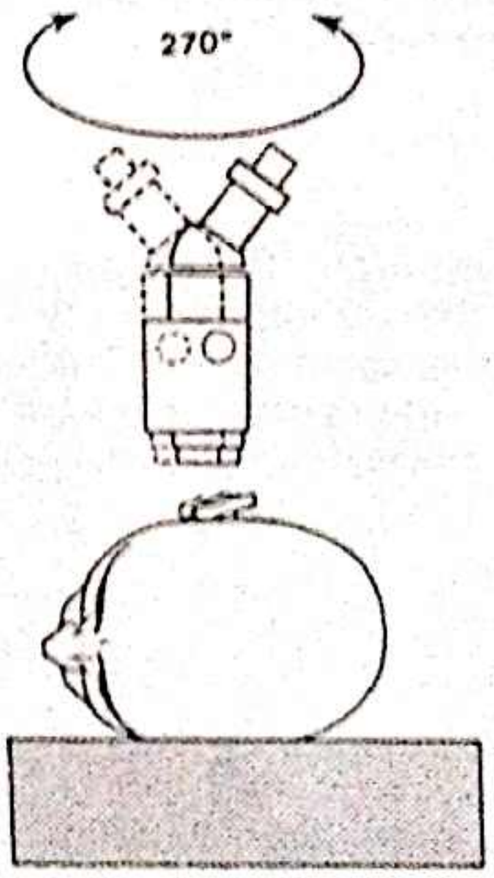
In order to approach the facial recess and sinus tympani, the patient's head is tilted 25° anteriorly, and the surgeon is positioned in front of the ear with the microscope stand behind the ear.



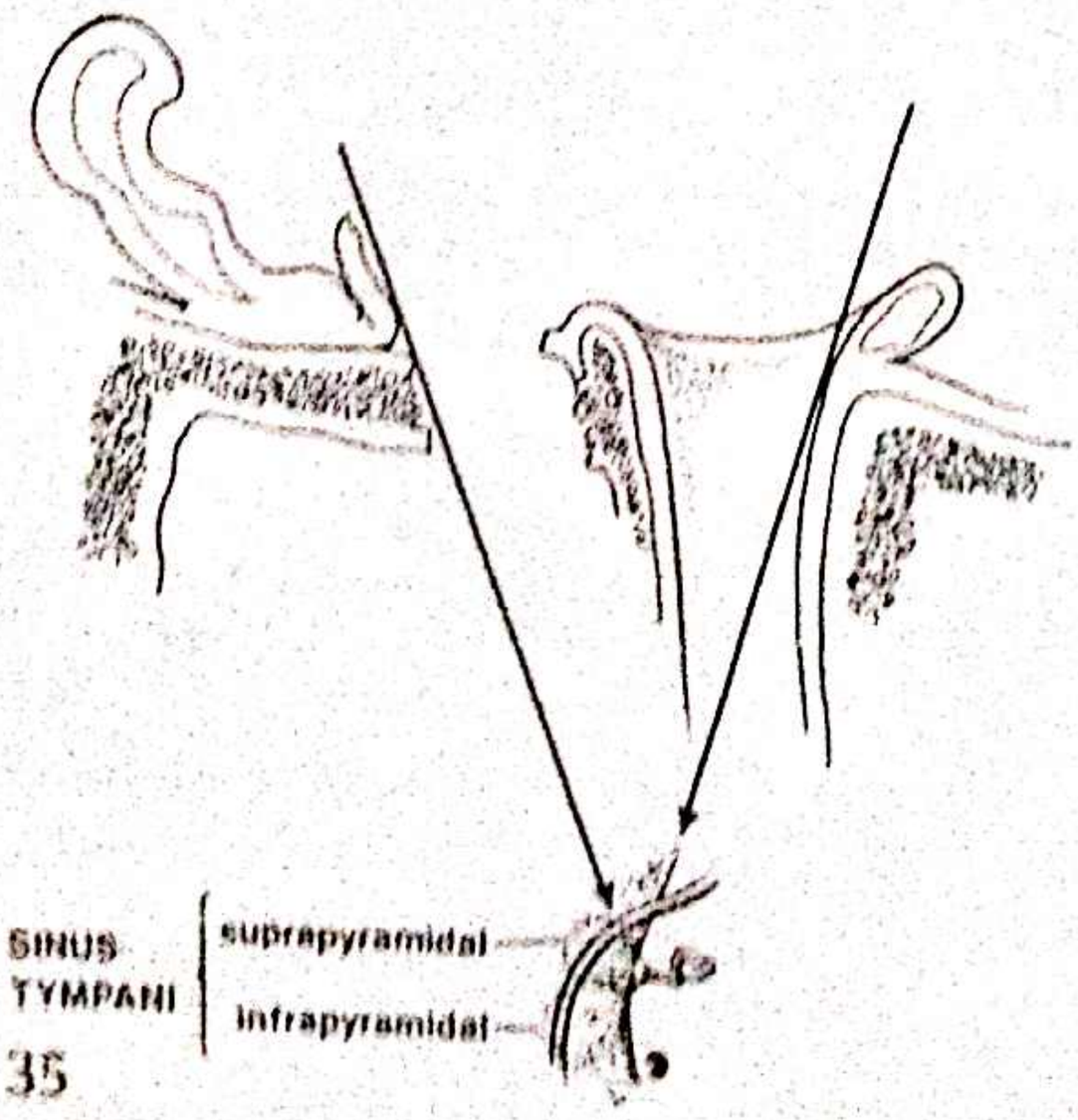
33

34

To view the entire tympanum, the position of the surgeon and that of the microscope is manipulated through 270°, thus circumnavigating the patient's head.



34



35

35

Visualization of sinus tympani

In order to obtain a clear view of the sinus tympani from an anteroposterior view, the annulus with the tympanic membrane is elevated from the sulcus. The deep posterior edge of meatal bone is curetted out – the extent of removal depends on the extension of the sinus tympani. The medial extension of the sinus tympani deep to the vertical portion of the facial nerve can best be seen following removal of the pyramidal process, ponticulus pyramidalis and subiculum. The hypotympanum and the area about the inferior extent of the sinus tympani are viewed in a cephalocaudal direction. If the deep posterior meatal edge requires extensive removal to gain good access, the resulting defect is repaired with tragal or homologous nasal cartilage.

ENDAURAL AND POSTAURAL HYPOTYMPANOTOMY

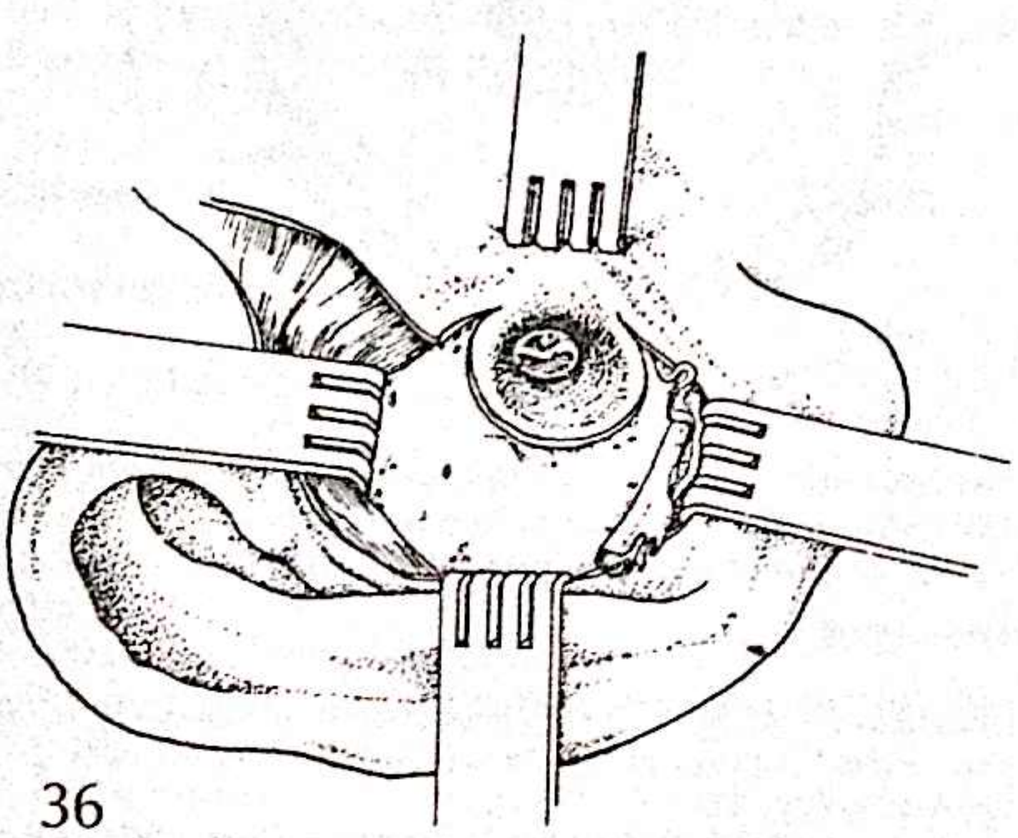
The endaural approach to the hypotympanum was first described by Shambaugh[5], who used it primarily for the removal of early glomus jugulare tumours confined to the hypotympanum. The technique was later modified by Farrior[6], who described the postauricular transcanal approach to the hypotympanum.

The main advantage of this approach is that it preserves hearing, yet allows an adequate exposure for the removal of the tumour.

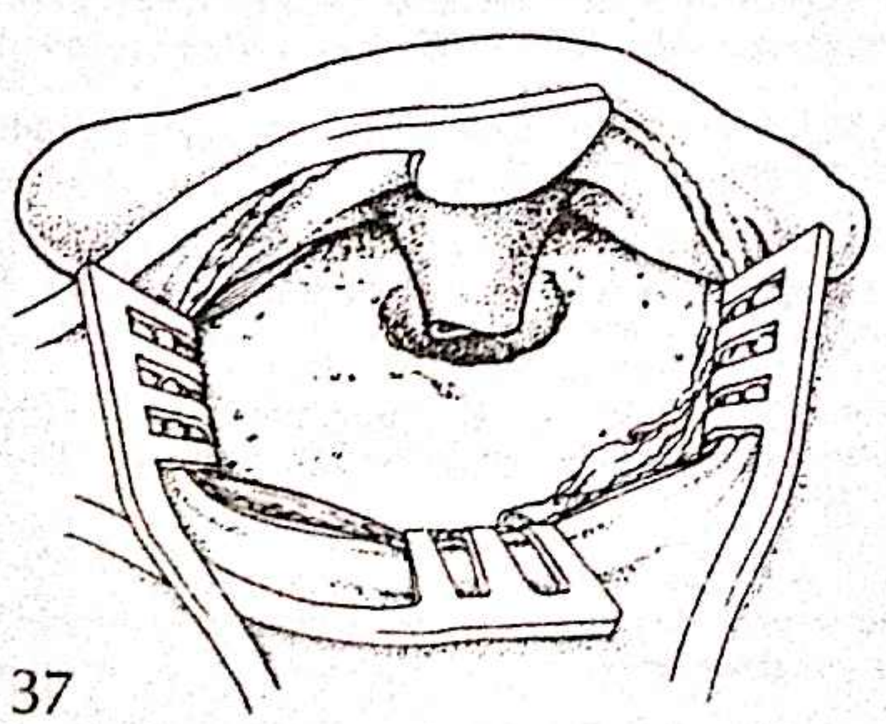
However, damage to the facial nerve is a real possibility and extreme care is required.

Preoperative

The ear is prepared as for the endaural approach.



36



37

Investigations

General investigations are as for the endaural approach. In addition arteriography, retrograde venography and tomograms of base of skull may be required to define the extent of the tumour. However, CT scanning is replacing these. Blood is grouped and cross-matched for possible replacement of blood loss at operation.

Anaesthesia

Premedication and anaesthesia are as for the endaural approach.

Instrumentation

As for the endaural and postaural approaches. A dermatome is required to obtain a partial thickness skin graft.

The operation

The patient is positioned as for the endaural approach.

The incisions

36

In addition to the endaural incision (*see Illustration 8*) Shambaugh[5] advocates a supplementary incision commencing at the caudal end of the meatal incision at 6 o'clock, and passing through the anterior and inferior canal skin so that a tympanomeatal flap can be raised and the middle ear space exposed.

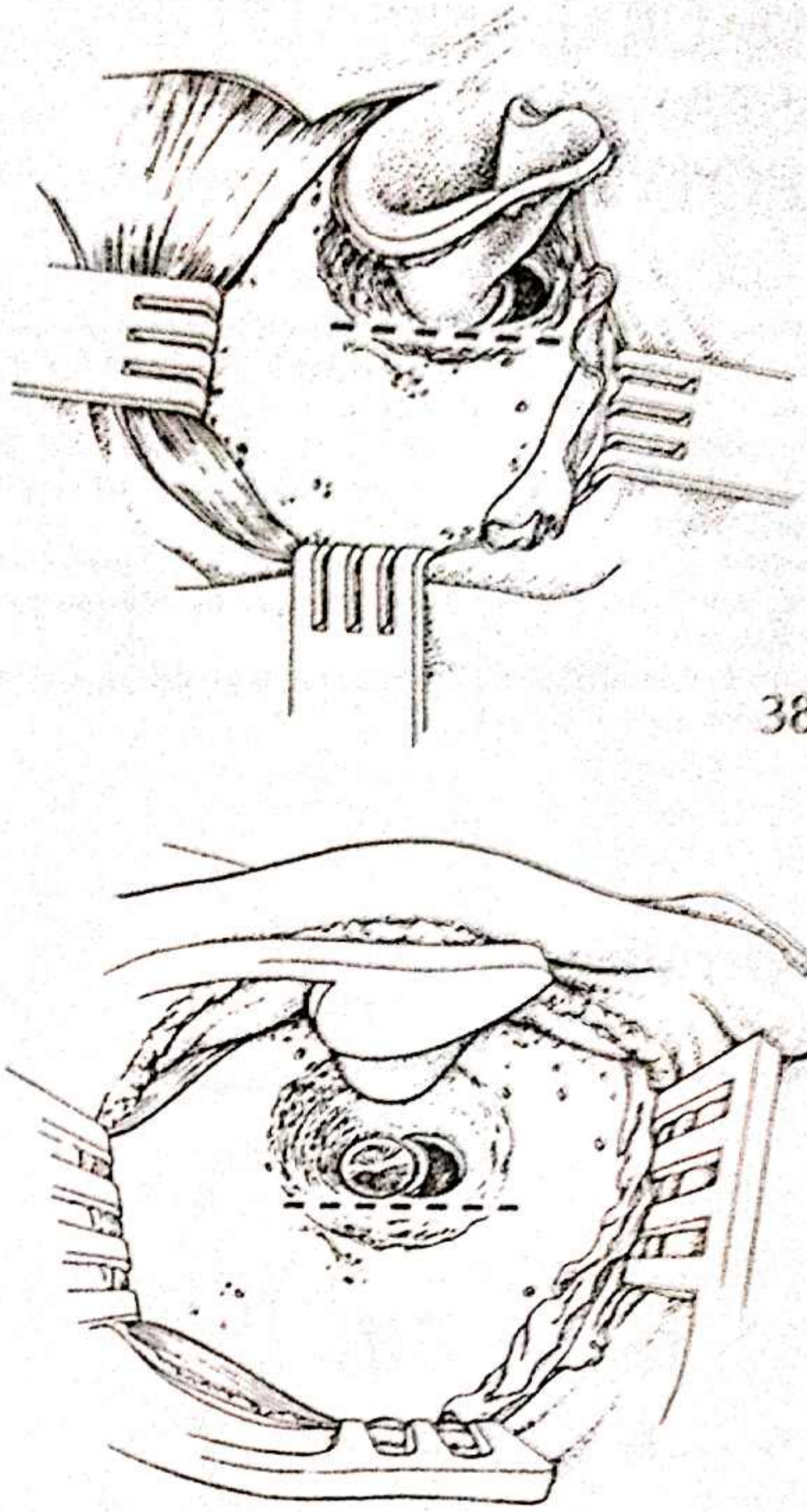
37

In the postauricular (*see Illustration 16*) approach to the hypotympanum[6] the inferior four-fifths of the canal skin up to the level of the tympanic membrane is excised and preserved. The annulus is elevated from the tympanic sulcus and the tympanic membrane reflected superiorly to expose the middle ear space. The greatest advantage of the postauricular transcanal approach to the hypotympanum is that the procedure can be converted into a radical mastoidectomy if the tumour proves to be extensive at exploration.

Exposure of hypotympanum

38 & 39

Using a suitably sized cutting burr, the bony meatus is enlarged mainly in the anterior and inferior walls while care is taken to avoid drilling the deep posterior meatal wall. The vertical course of the facial nerve is delineated by an imaginary vertical line through the posterior edge of the sulcus tympani. The bone work is carried out anterior to the imaginary vertical line. Farrior[6] advocates tracing the chorda tympani posteriorly to its origin from the facial nerve and thus defining the anterior surface of the vertical segment. The dissection is completed by excision of the inferior segment of the tympanic sulcus and wide exposure of the hypotympanum.



38

39

Closure of wound

The tympanomeatal flap (or the tympanic membrane) is replaced. It is an advantage to line the hypotympanum with a temporalis fascia graft. The exposed meatal bone is covered over with a split-thickness skin graft. The meatus is packed with BIPP ribbon gauze. The upper part of the endaural skin incision is closed by interrupted silk stitches. A firm mastoid bandage is applied, keeping the contralateral ear free from the edge of the bandage.

Postoperative care and complications are as for the endaural approach.

Acknowledgement

Illustration 25 has been modified from Thorburn.

References

1. Donaldson, J. A., Anson, B. J., Warpeha, R. L., Rensink, M. J. The surgical anatomy of the sinus tympani. Archives of Otolaryngology 1970; 91: 219–227

2. Jansen, C. The combined approach for tympanoplasty. Journal of Laryngology 1968; 82: 779–793

3. Jako, G. J. The posterior route to the middle ear: posterior tympanotomy. Laryngoscope 1967; 77: 306–316

4. Goodhill, V. Circumferential tympano-mastoid access. The sinus tympani area. Annals of Otology, Rhinology and Laryngology 1973; 82: 547–554

5. Shambaugh, G. E. Jr. Surgical approach for so-called glomus jugulare tumours of the middle ear. Laryngoscope 1955; 65: 185–198

6. Farrior, S. B. Glomus tumours. Post-auricular hypotympanotomy and hypotympanoplasty. Archives of Otolaryngology 1967; 86: 367–373

Illustrations by Gillian Lee

Cortical mastoidectomy

Joselen Ransome MB, BS, FRCS
Consultant Otolaryngologist, Charing Cross and Metropolitan Ear, Nose and Throat Hospitals, London, UK

The aim of the operation is to exenterate the mastoid aircell system as completely as possible.

Indications

Acute mastoiditis

Surgery is indicated:

1. when the symptoms and signs have not been controlled by an adequate course of an appropriate antibiotic;
2. in patients with the following complications at presentation:
   (*a*) intracranial complications;
   (*b*) subperiosteal or subcutaneous abscess in the postauricular region;
   (c) labyrinthitis;
   (*d*) Bezold's or Citelli's abscess in the neck,
3. when the acute symptoms and signs subside but otorrhoea continues 3–4 weeks after the onset.

Note: It is rarely necesary to perform a cortical mastoidectomy in cases of acute mastoiditis presenting with facial paralysis, as both conditions will usually resolve with adequate antibiotic treatment.

Secretory otitis media and idiopathic haemotympanum

There are conflicting views as to whether these are two conditions or one, and whether cortical mastoidectomy has a place in their management. However, there have been reports of patients in whom granulations were found at operation in the mastoid aircells. Rarely, the operation should be contemplated in very persistent cases of secretory otitis media and 'blue drum', accompanied by marked hearing loss, which continues to recur despite frequent insertion of grommets.

Tuberculous mastoiditis

This now very rare infection occasionally presents as acute mastoiditis, the tuberculous nature is rarely diagnosed preoperatively. It should be suspected in known tuberculous patients or if pale granulations are found at operation in the mastoid antrum and aircells.

Preoperative

Investigations

The following should be carried out before operation whenever possible.

1. *General examination* to assess fitness for general anaesthesia.
2. *Central nervous system examination* if intracranial complications are suspected.
3. *Examination of facial movements* to exclude preoperative facial paralysis.
4. *Full blood count* for comparison with postoperative results. A rising total white cell count generally indicates that the disease or its complications are uncontrolled. The haemoglobin concentration is of particular importance in children.
5. *Ear swab* (when otorrhoea is present) for bacterial culture and sensitivity determination so that appropriate antibiotic therapy can be given. This is of the utmost importance if intracranial complications are present or suspected.
6. *Mastoid X-rays* primarily to give the surgeon a useful guide to the extent of the aircell system and the positions of the middle and posterior fossa dura.
7. *A pure tone audiogram* to serve as a baseline against which to measure postoperative progress.

Antibiotics

Appropriate antibiotic treatment in adequate dosage must always be instituted before operation. If there are intracranial complications an antibiotic or sulphonamide which attains a high concentration in the cerebrospinal fluid must be included.

Preparation

Since a postauricular incision is used, the hair should be drawn away from this area and held by adhesive tape; this can conveniently be done with Sellotape. If the hair grows close to the groove it can be shaved 2–3 cm behind and above the pinna.

Anaesthesia

Premedication will always be required as for any other operation requiring general anaesthesia.

A general anaesthetic with endotracheal intubation is given.

The operation

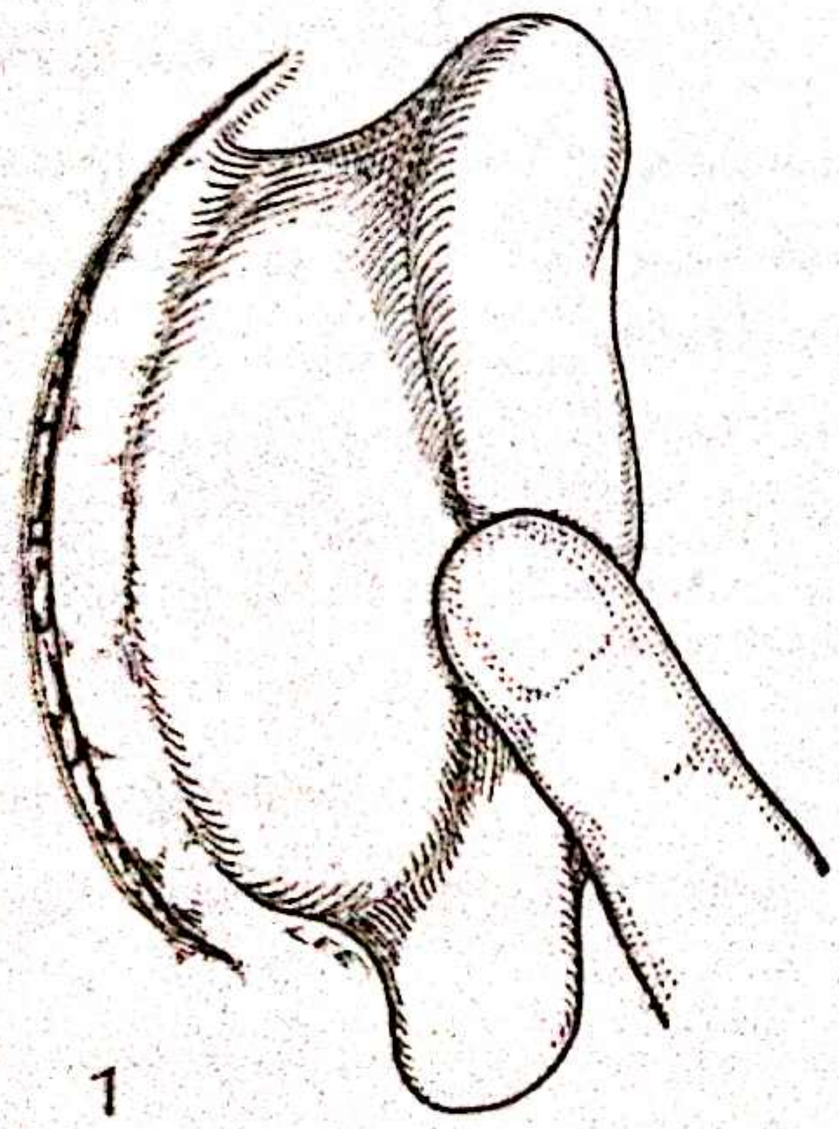
The patient is placed supine on the operating table with the head turned as far as possible to one side and held in position by a ring.

1

A curved incision is made through the skin of the postauricular region a few millimetres behind and parallel to the postauricular groove.

Care must be taken (1) in the lower half of the incision in infants, in whom the mastoid process is undeveloped, and the facial nerve, as it leaves the stylomastoid foramen, is therefore superficial; (2) in the upper half of the incision: the lower border of the temporalis muscle should be identified and conserved whenever possible. If it is necessary to incise it to obtain adequate exposure, the vessels running at its lower border are first ligated or diathermized (*see Illustration 3*).

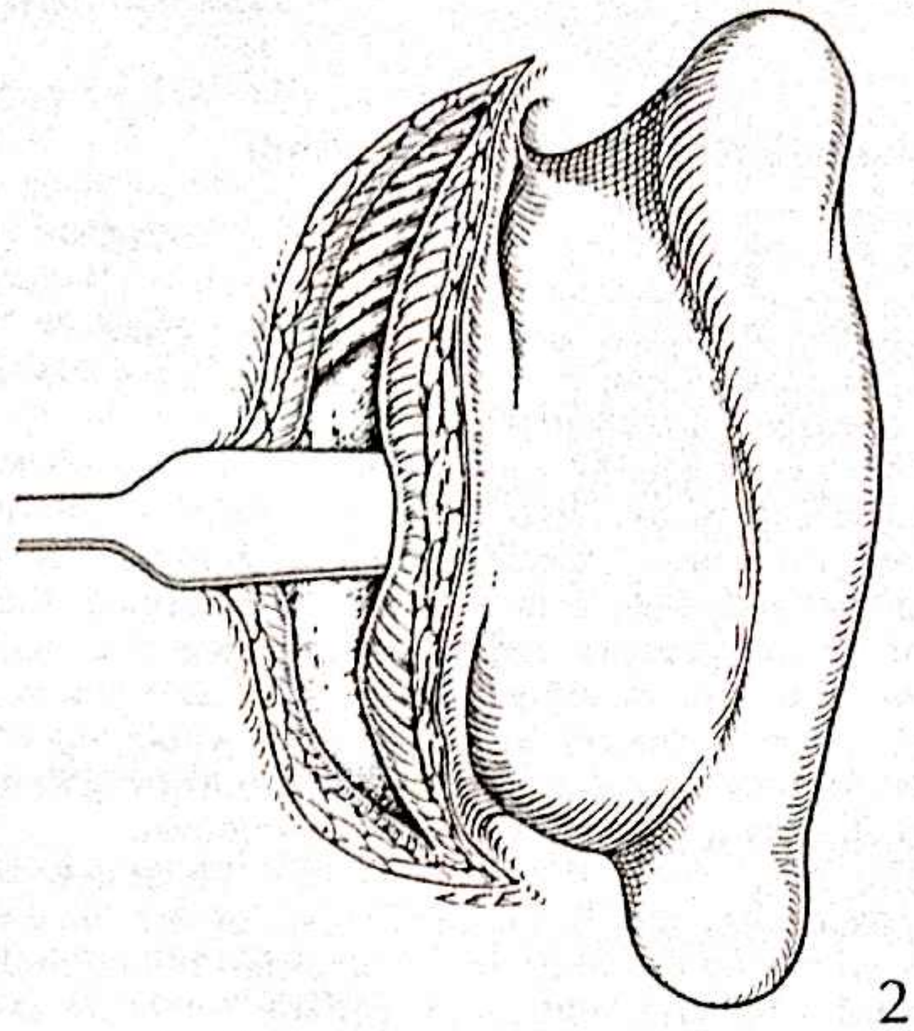
In older children and adults the tendon of the sternomastoid muscle has a wide attachment to the superficial aspect of the mastoid process: the fibres are scraped off with a periosteal elevator. Between the temporalis muscle and the sternomastoid the soft tissues (including vestigial postauricular muscles and periosteum) are incised down to the bone.



1

2

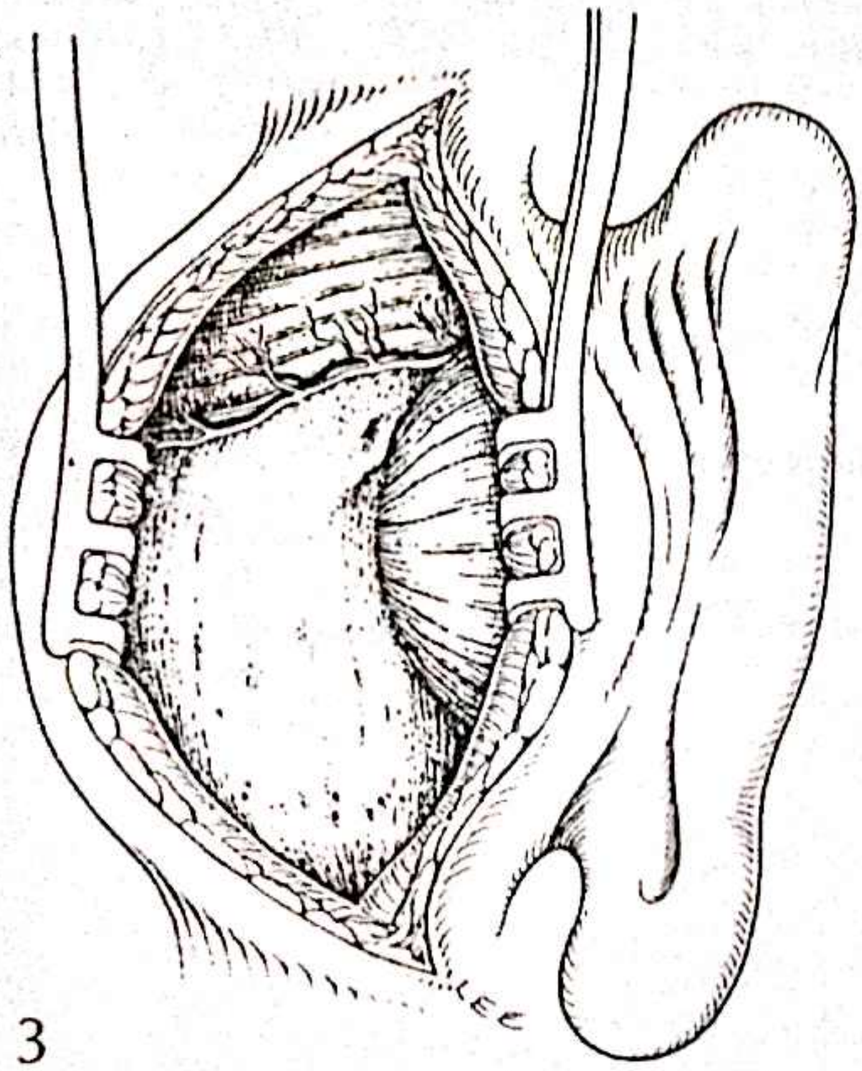
The periosteum is elevated forwards as far as the lateral end of the posterior bony meatal wall, backwards for a few millimetres, and upwards (pushing up the temporalis muscle at the same time) to the level of the upper attachment of the pinna.



2

3

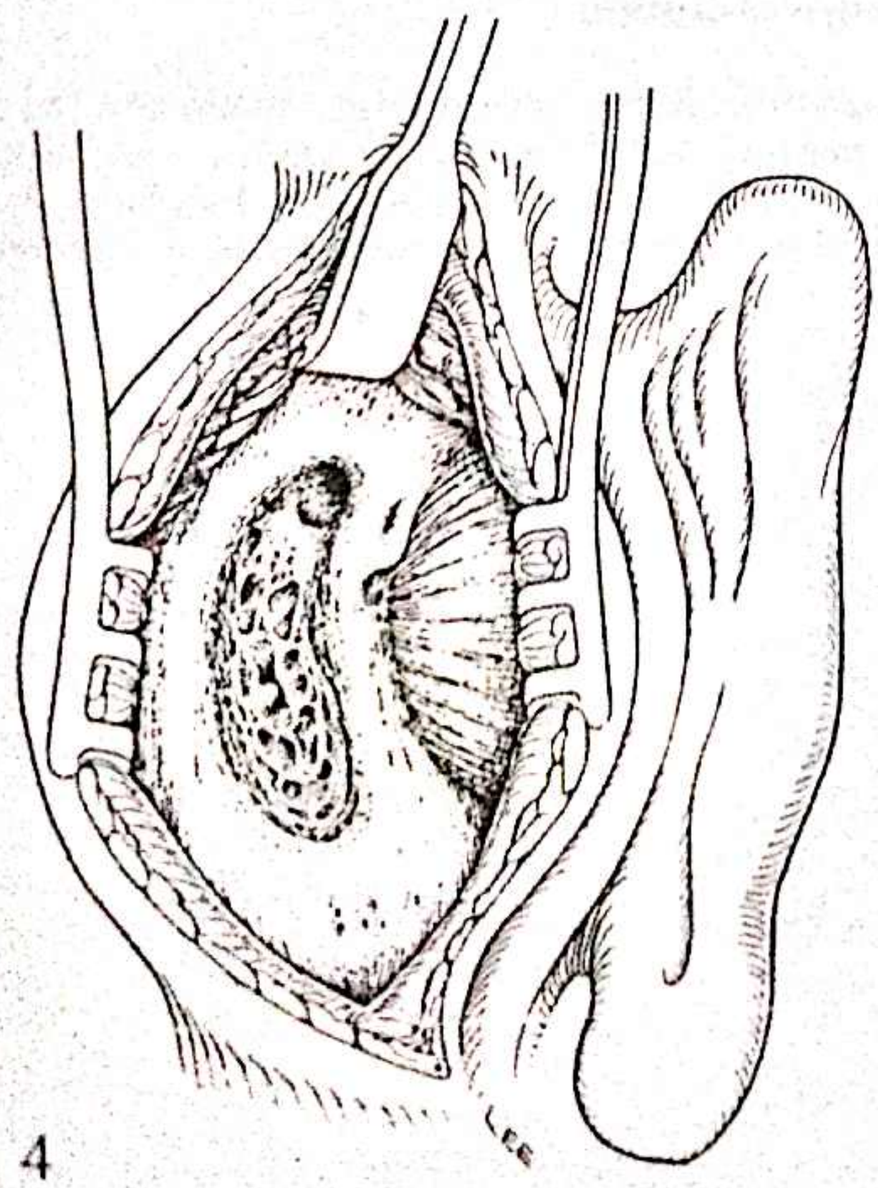
All bleeding points are secured and a self-retaining retractor is inserted.



3

Exposure of the mastoid antrum

In exenterating part of the mastoid bone to uncover the antrum it must be remembered that (*1*) the antrum is at a depth of 15 mm in the adult, but only a few millimetres in the infant; (*2*) the surface marking of the antrum is McEwen's triangle; and (*3*) the position of the middle and posterior fossa dura can be judged by examining the lateral oblique X-ray of the mastoid.



4

Bearing in mind these landmarks and using either a drill or a mallet and gouge, bone is gradually removed until the antrum is exposed.

If pus is encountered a further swab is taken and sent for culture. To confirm that the antrum – rather than merely a large cell – has been entered, a small Dundas Grant probe is passed into the aditus. This should be done gently to avoid dislodging the short process of the incus. At the same time the size of the aditus can be judged; if it is very small it may be enlarged slightly with a fine bone curette to ensure adequate drainage of the middle ear.

Note: the bony posterior meatal wall must be preserved, and the skin is not dissected off it.

5

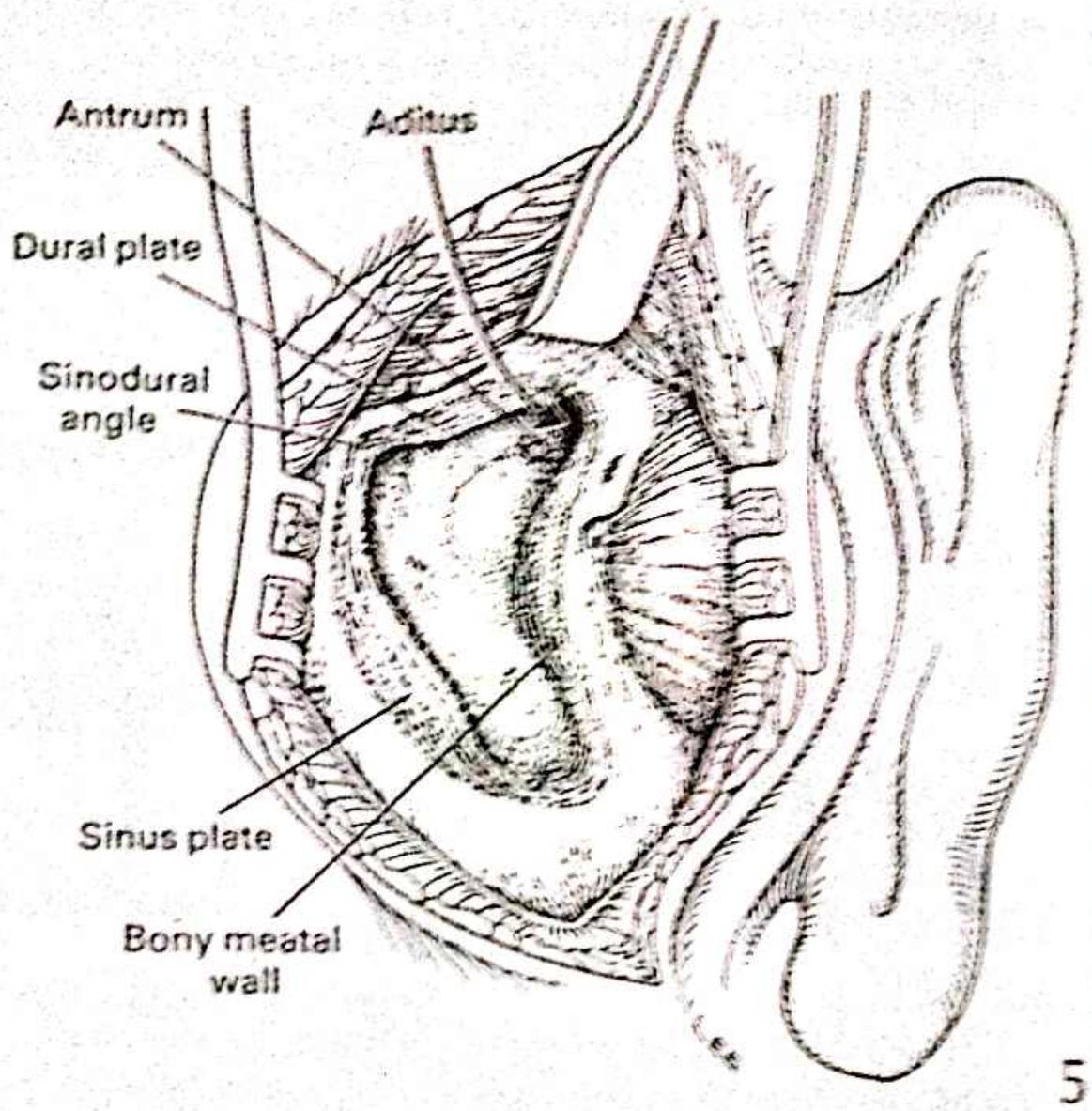
Completion of air cell exenteration

The aircells are now followed and removed in every direction. It is particularly important to clear all the cells from the sinodural angle. The smooth plate of bone covering the middle fossa dura above and the lateral sinus posteriorly is usually easily recognized.

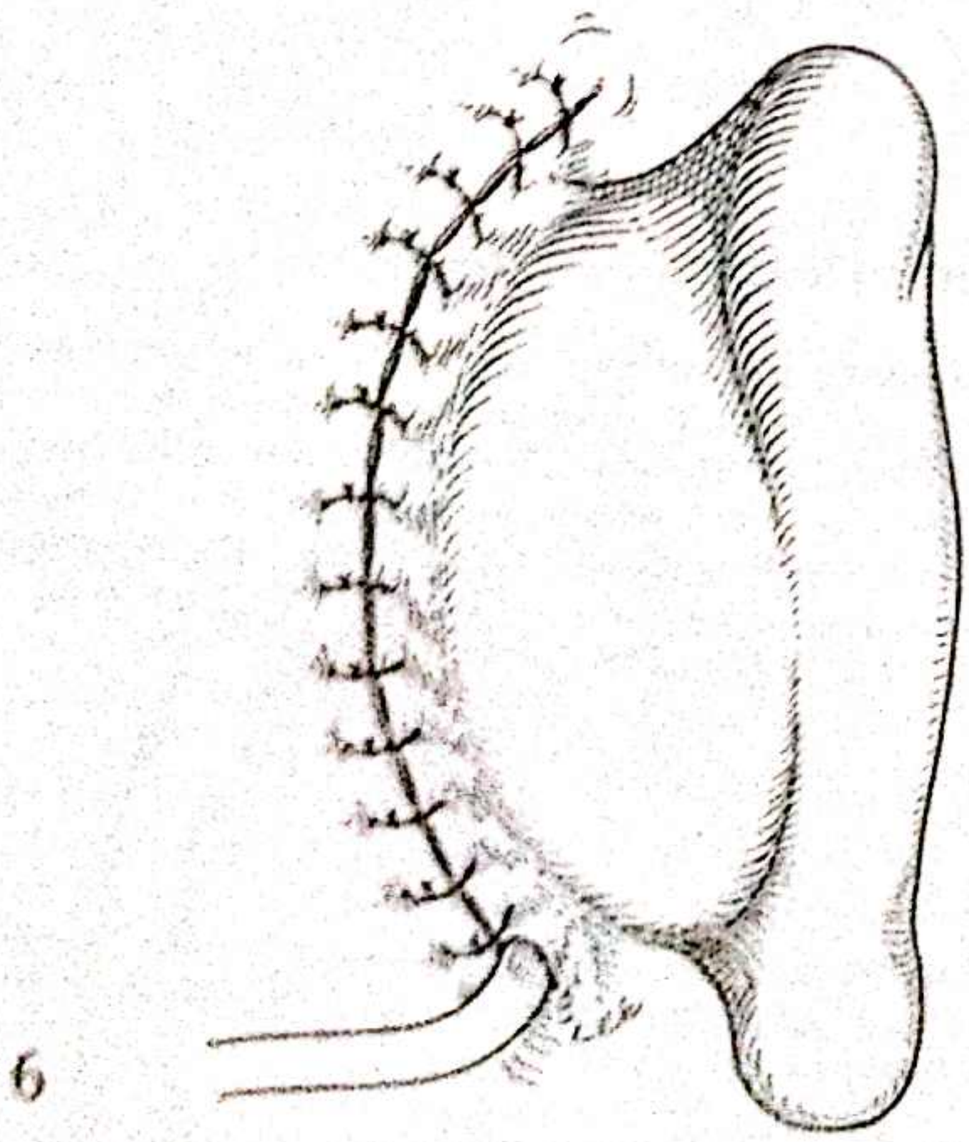
There is frequently a group of cells in relation to the vertical part of the facial nerve which are best removed using the Zeiss operating microscope. In a well-pneumatized skull, cells may extend anteriorly into the root of the zygoma and posteriorly into the occipital bone; these too must be followed as far as is practicable.

It is not necessary to remove the whole tip of the mastoid process unless it is necrotic, but the lateral wall and all cells up to the tip should be removed.

The bony cavity thus created has the antrum as its deepest point, and is bounded above by the dural plate, posteriorly by the sinus plate and anteriorly by the bony meatal wall and aditus. In patients with intracranial complications, a small area of both middle fossa dura and lateral sinus should be exposed; if this reveals granulations or an extradural abscess, exposure of dura is continued until healthy dura is found.



5



6

Closure of wound

A small drain is inserted into the antrum and led out near the mastoid tip. The skin is closed with interrupted sutures, and a dressing pad and bandage should be applied firmly to prevent a subcutaneous haematoma.

5

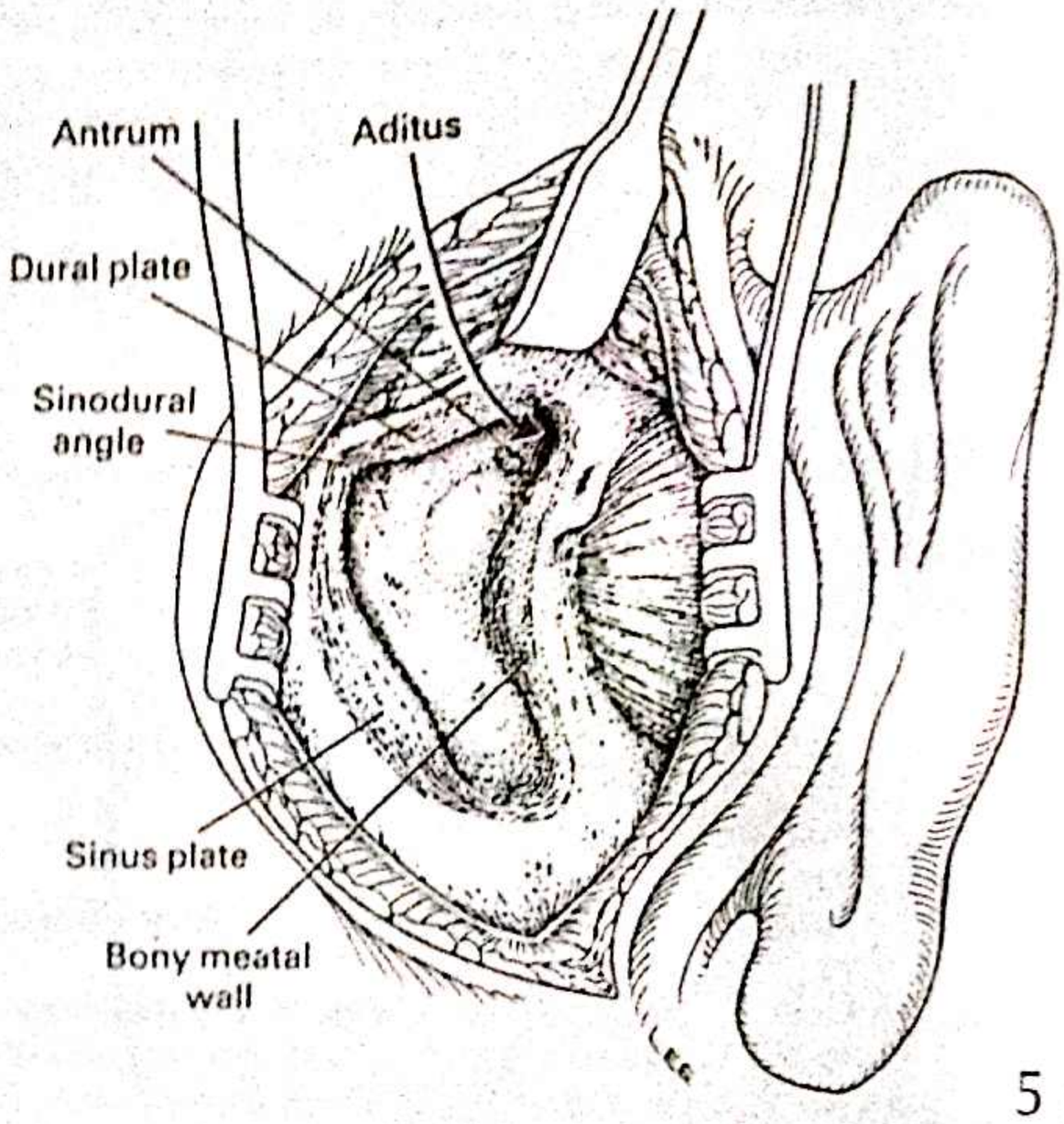
Completion of air cell exenteration

The aircells are now followed and removed in every direction. It is particularly important to clear all the cells from the sinodural angle. The smooth plate of bone covering the middle fossa dura above and the lateral sinus posteriorly is usually easily recognized.

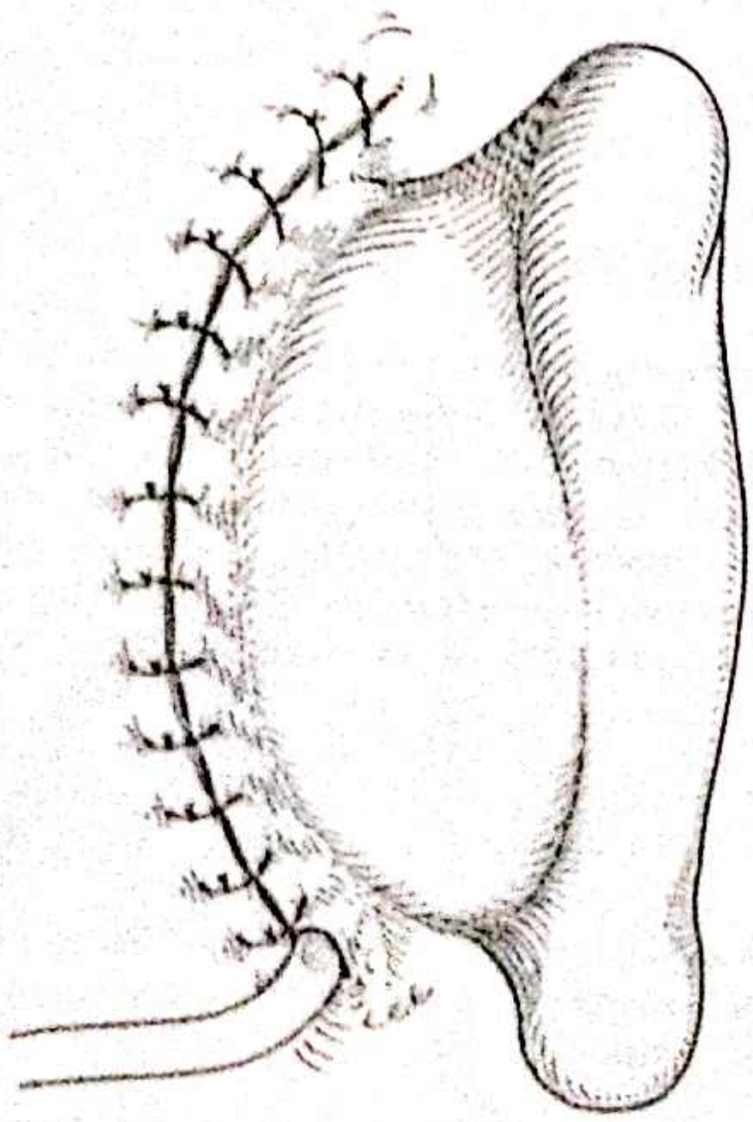
There is frequently a group of cells in relation to the vertical part of the facial nerve which are best removed using the Zeiss operating microscope. In a well-pneumatized skull, cells may extend anteriorly into the root of the zygoma and posteriorly into the occipital bone; these too must be followed as far as is practicable.

It is not necessary to remove the whole tip of the mastoid process unless it is necrotic, but the lateral wall and all cells up to the tip should be removed.

The bony cavity thus created has the antrum as its deepest point, and is bounded above by the dural plate, posteriorly by the sinus plate and anteriorly by the bony meatal wall and aditus. In patients with intracranial complications, a small area of both middle fossa dura and lateral sinus should be exposed; if this reveals granulations or an extradural abscess, exposure of dura is continued until healthy dura is found.



5



6

6

Closure of wound

A small drain is inserted into the antrum and led out near the mastoid tip. The skin is closed with interrupted sutures, and a dressing pad and bandage should be applied firmly to prevent a subcutaneous haematoma.

Postoperative care

As soon as the patient is conscious, the facial movements are examined to exclude operative damage to the facial nerve. Antibiotic therapy is continued, and decongestants, both systemic and local, are added to promote drainage of the middle ear cleft via the Eustachian tube.

The patient's temperature should be taken every 4 hours. It usually falls dramatically within the first 24 hours, when the patient can be allowed up.

The *drain* should be removed when there is no further discharge either through the wound or through the external meatus. In practice this is usually after 2–3 days, but the drain should be left longer if necessary.

The *sutures* can be removed on the 5th–7th day.

A postoperative audiogram is obtained as soon as the ear is dry. At this stage there should be some improvement, though normal hearing may not be regained until 2–3 weeks after the operation.

Complications

Complications of the operation are few and due mainly to errors of technique.

Persistent deafness

This may be due to the following:

1. Incus dislocation or removal. The ear becomes dry and the tympanic membrane heals but conductive deafness persists. Impedance audiometry indicates disruption of the ossicular chain. Anterior tympanotomy and reconstruction of the ossicular chain may be carried out.
2. Persistent infection due to residual cells. This should resolve with proper medical treatment and good drainage. However, if it persists, reopening of the mastoid and exenteration of the remaining cells is required.

Complete facial nerve paralysis

If present immediately postoperatively but not preoperatively, the facial nerve has been damaged at operation, and the mastoid must be reopened and the vertical part of the facial nerve explored.

Meatal stenosis

This may occur if the bony meatal wall is taken down and the skin dissected off the bony wall. It requires excision of the stenosed area and firm packing of the canal until re-epithelialization occurs.

Illustrations by D. J. Hammersley

Epitympanotomy and tympanomastoidectomy

J. D. K. Dawes MD, FRCS
Reader in Otolaryngology, University of Newcastle upon Tyne, UK

Terminology

The old terms 'modified radical' and 'radical mastoidectomy' hold different meanings for different surgeons and fail to give an adequate description of the surgical exposure. A more accurate anatomical description of the bony exposure would be as follows.

Epitympanotomy (atticotomy) – exploration of the epitympanum or attic.

Epitympanomastoidectomy (attico-antrostomy) – exploration of the epitympanum, mastoid antrum and air cells without major interference to the annulus tympanicus, membrana tensa or tympanum.

Tympanomastoidectomy – exploration of the mastoid antrum, air cells and the tympanum and its appendages. Further removal of bone to expose dura, lateral sinus, jugular bulb, sinus tympani and hypotympanum should also be noted. As the surgical approach depends on the anatomy of the temporal bone, the extent of the disease, the degree of ossicular damage, the state of the facial and semicircular canals and of the Eustachian tube, and the type of mucosal disease, all these features should be accurately recorded.

Indications

The main indication for surgical exploration is to gain adequate or even wide access to a cholesteatoma in cholesteatomatous chronic otitis so that its matrix and associated granulomatous disease may be completely excised before reconstruction of the ossicular chain, sealing of the tympanum or rebuilding of the posterior meatal wall.

Occasionally a similar approach is undertaken to control mucosal or granulomatous disease involving the tympanomastoid portion of the middle ear cleft.

Surgical aims

The objects of the operation in order of clinical importance are:

1. to control or prevent otogenic suppurative intracranial complications;
2. to obtain a dry ear when it has been persistently discharging;
3. to preserve useful hearing or restore hearing to a useful level.

Ideally, as cholesteatoma is an insidiously progressive erosive disease, no fragment of excisable matrix should be left. However, if the cholesteatoma has spread into the intracranial tissue planes, the internal auditory meatus, the labyrinth, the cochlea or extensively into the peritubal cells it may not be possible to remove the disease completely. The presence of a postoperative cavity enables the desquamated debris and purulent discharge to be removed, so controlling the disease in almost every case. Although cholesteatoma may have exposed the membranous labyrinth or the facial nerve, or partially eroded the footplate of the stapes, in most cases the matrix can be skilfully dissected with safety, but the relatively inexperienced surgeon may deem it wiser to leave the matrix in case a 'dead' ear or permanent facial nerve paralysis should result. Judgement must be exercised in each case according to the extent of the disease and skill of the surgeon. Without doubt, however, operations in which the whole matrix is removed offer a much better prospect of dry ears and improvement of hearing by reconstructive techniques.

Advantages

A tympanomastoidectomy is always technically possible and therefore has a more universal application than the intact posterior meatal wall technique in the management of chronic otitis. The extent of the surgical exploration can be modified according to requirements, and wide access for exposure of the tympanomastoid segment of the middle ear cleft can be obtained. When cholesteatoma cannot be completely excised, or when it is deemed unwise to do so, the cavity excavated allows postoperative access for toilet.

Disadvantages

A postoperative cavity takes longer to heal, and even after healing patients need to attend annually or biannually for removal of wax.

In a few cases the cavity remains infected, requiring frequent toilet or revision operation. However, persistent discharge from the cavity is often due to residual disease in the tympanic segment, particularly in the regions of the sinus tympani and peritubal cells, both of which are not readily accessible with the intact posterior meatal wall technique.

Another criticism is that a shallower middle ear results, making reconstruction of the ossicular chain physically less effective.

A common feature of unsatisfactory tympanomastoid cavities is that they are large, access is restricted by a high facial ridge, the disease has been inadequately removed, and the Eustachian tube and neighbouring part of the tympanum have not been sealed off from the rest of the cavity.

Although a cavity cannot be avoided in tympanomastoidectomy it does not of necessity have to be large. It should be made large enough to excise all disease and can be allowed to contract postoperatively. Access to the cavity is readily attained if the facial ridge has been extensively lowered so that postoperatively the posterior wall of the meatus, thus creating the impression of looking into an expanded meatus. Such a cavity heals in about 1–2 months and is lined by a thin self-cleansing epithelium. Postoperative care can be minimal.

Anaesthesia

A general anaesthetic with endotracheal intubation is used. If there are no contraindications, hypotension should be maintained.

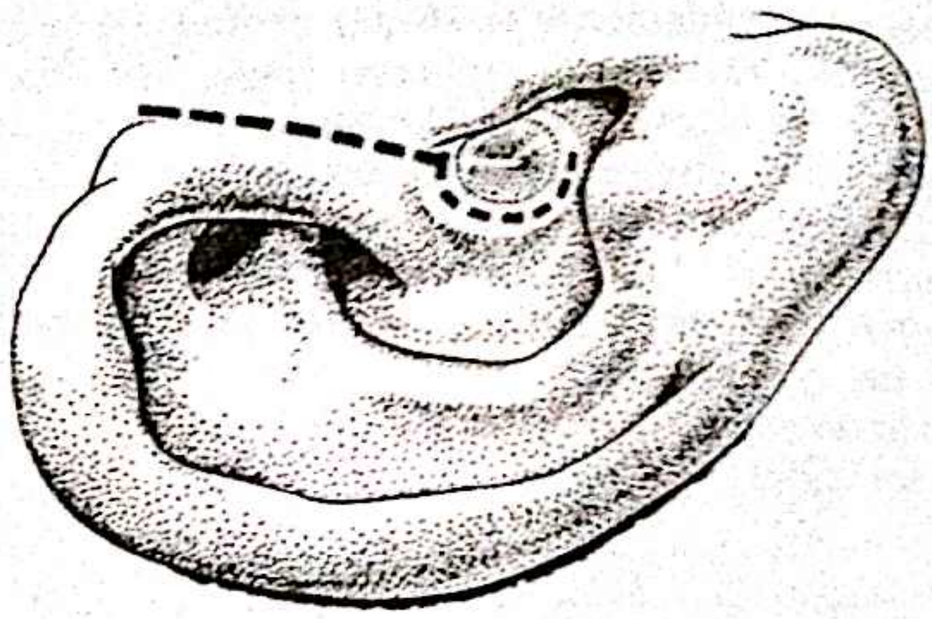
Position of patient

The table is angled foot down and the headpiece is tilted so that the patient's head is horizontal. The head is supported by a padded ring. The table should also be capable of side tilt.

The operations

Incisions

The mastoid cortex may be exposed by an endaural or a postaural incision. The endaural incision has some advantages in that it gives more direct access to the external auditory meatus and tympanum, permits more accurate cutting of meatal skin flaps, allows a better assessment of the accessibility and shape of the cavity with respect to the meatus at the end of the operation and, if the incision is correctly placed, leaves an almost invisible scar.

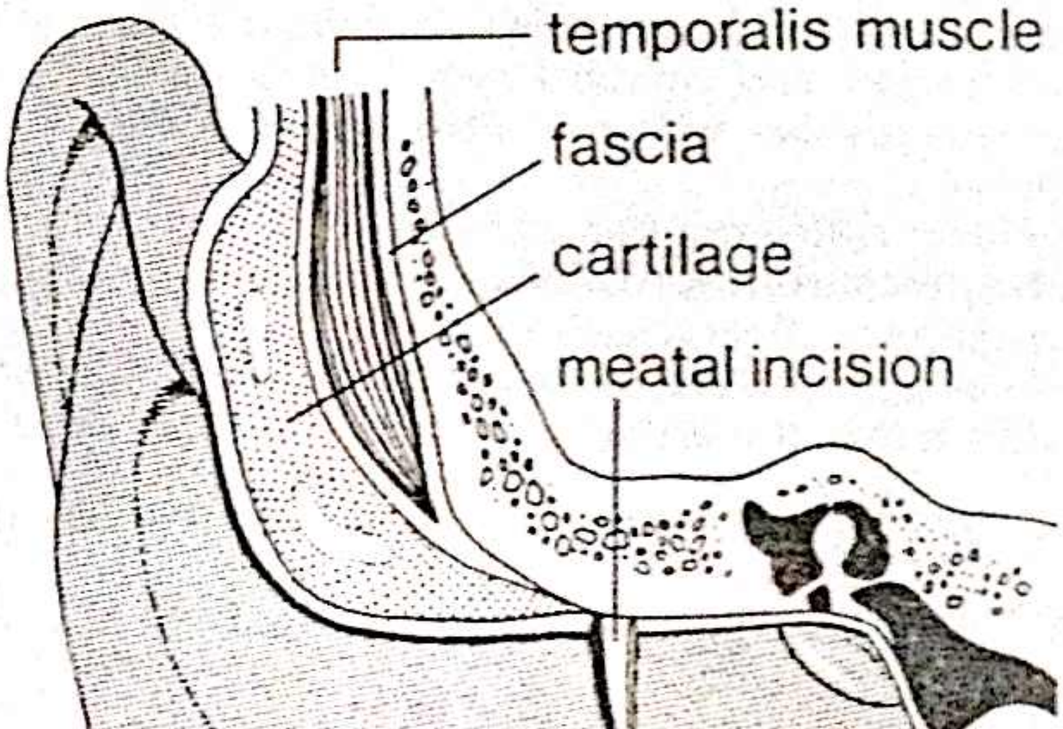


1

ENDAURAL INCISION

1

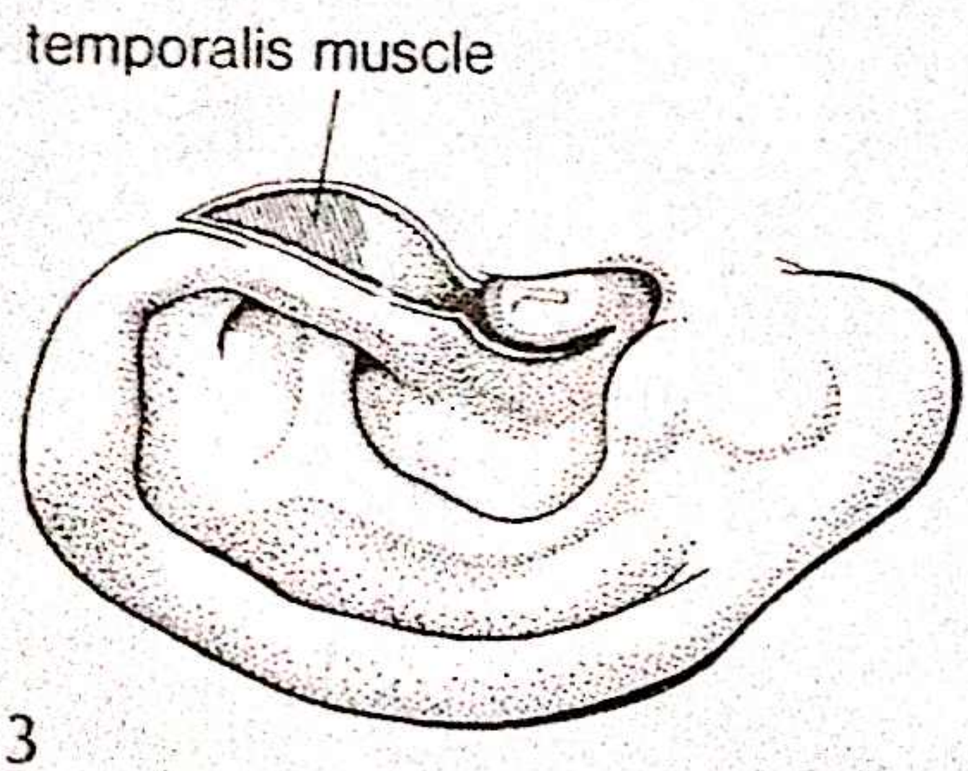
The incision is carried out in two steps. The first incision is made from the bony meatus at 12 o'clock outwards between the helical and tragal cartilages and carried upwards parallel to the helix. The second incision is circular within the meatus and extends from 1 or 2 o'clock (on the right side) to 6 o'clock.



2

2

The second incision is carried through the meatal skin medial to the gland-bearing portion and directly on to bone.



3

Exposure of temporalis

3

The prehelical incision is deepened by cutting through the anterior auricular muscle to the level of the temporalis fascia above, and down to the bone within the meatus.

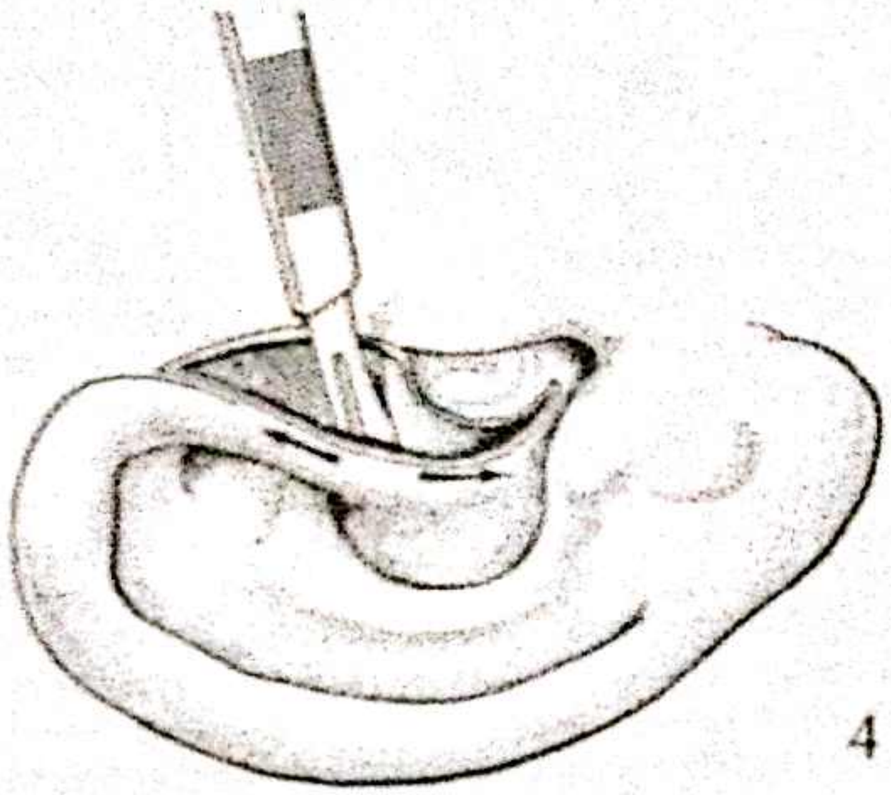
Freeing of pinna

4

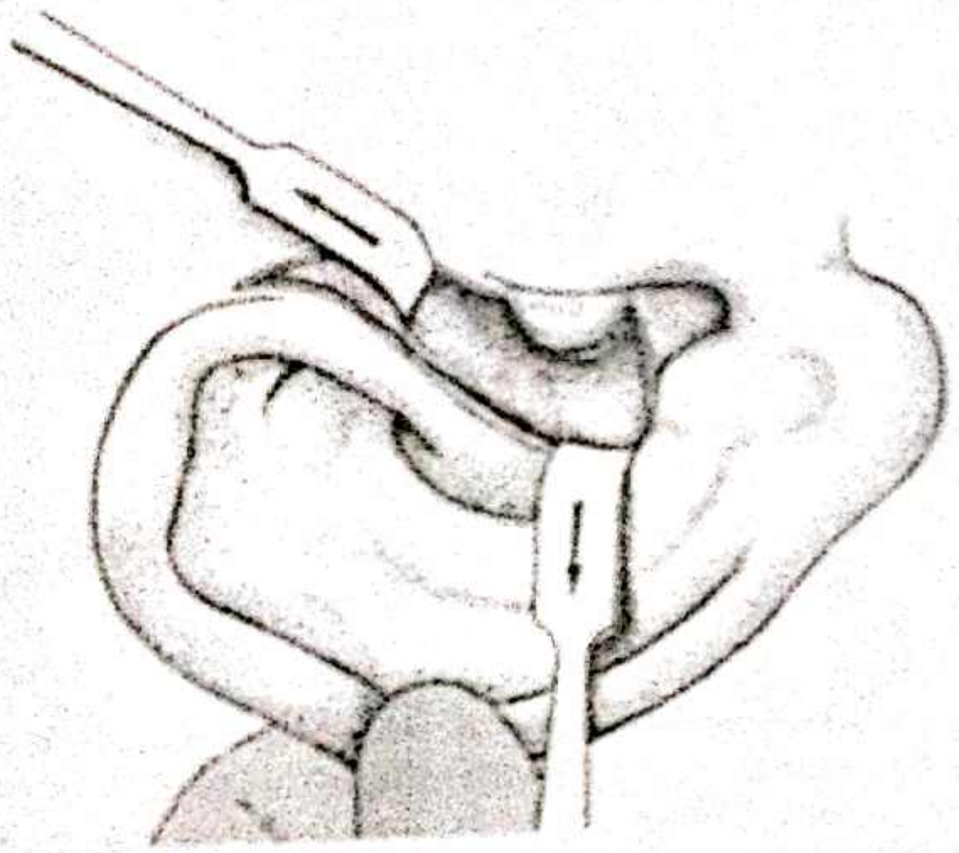
The pinna is now freed from the temporalis fascia and periosteum by division of the fibrous attachment to these tissues and the outer cuff of skin is dissected backwards in continuity with the pinna. The undercutting of the incision should also be carried forwards to free the meatal skin and temporalis fascia from the anterior edge of the prehelical incision.

The mobility of the pinna and the subsequent degree of exposure of the mastoid cortex depend on the extent of undercutting and the length of the prehelical incision which, if necessary, can be lengthened around the upper root of the pinna.

A fascial graft can now be taken from the temporalis or deferred until the later stages of the operation.



4

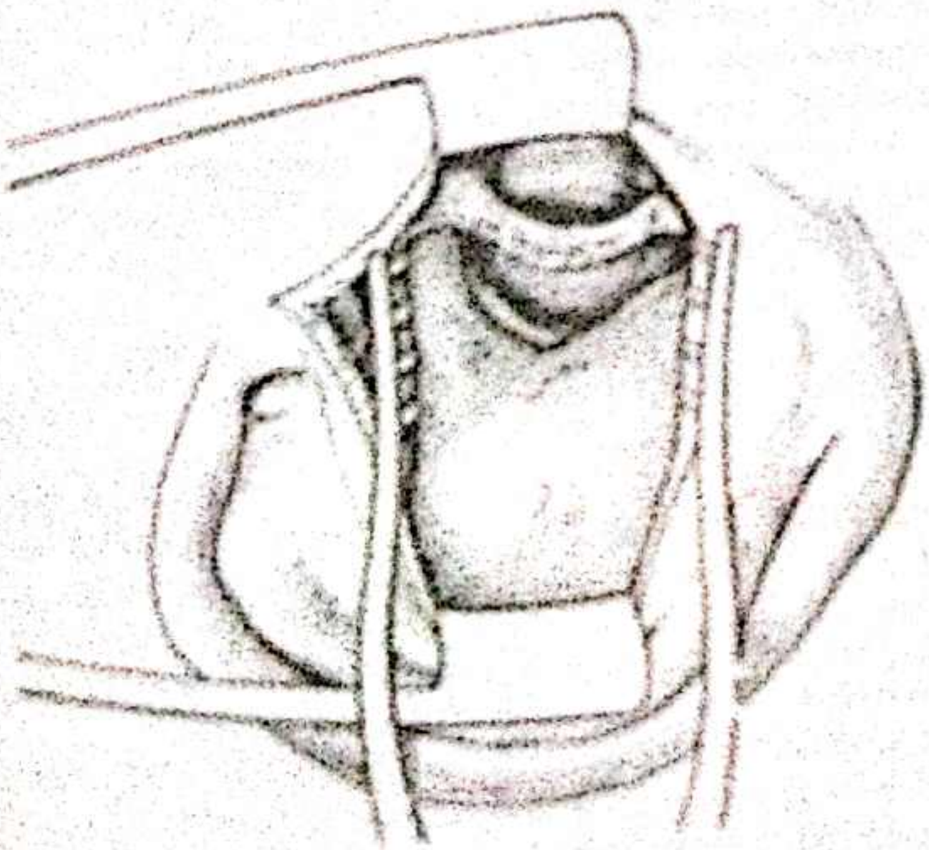


5

Elevation of periosteum

5 & 6

The periosteum and temporalis muscles are next elevated in an upward and backward direction to expose the mastoid cortex. Any excess connective tissue at the bony entrance to the meatus should also be removed. Self-retaining retractors are inserted.



6

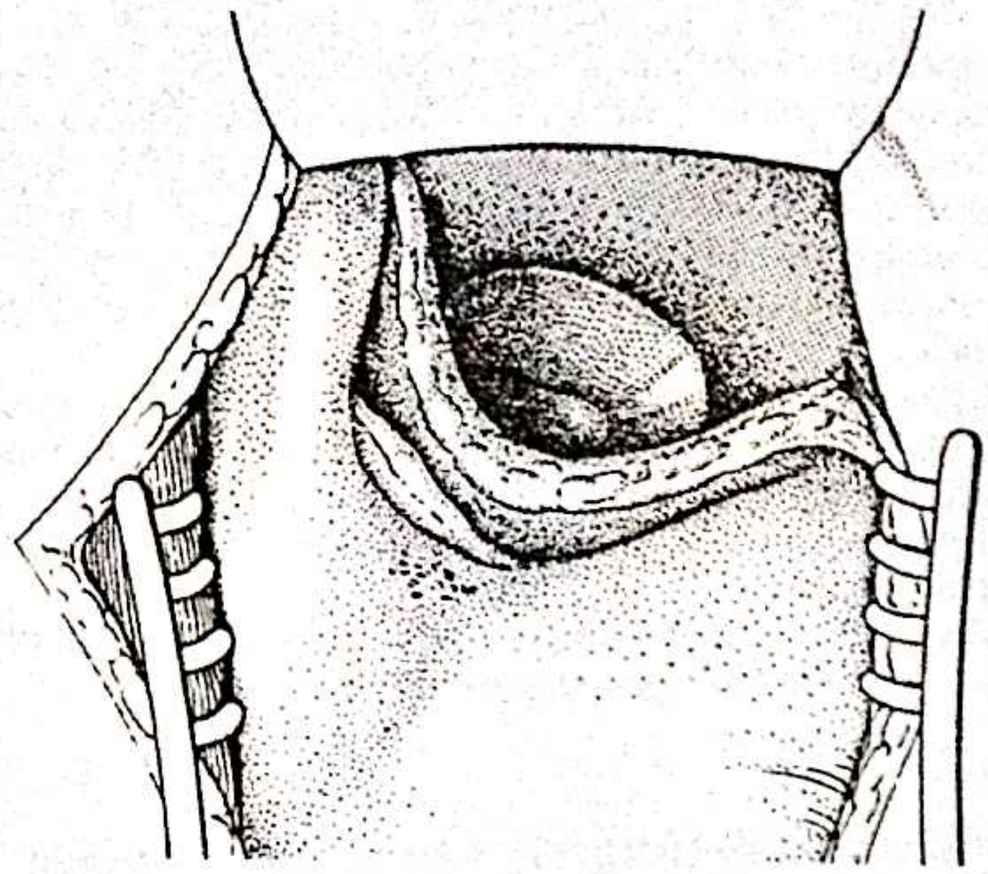
Freeing of meatal skin cuff

7

The anterosuperior edge of the meatal skin cuff should be released from the anterior edge of the prehelical incision, the underlying temporalis and the endomeatal spine by sharp dissection to allow a direct view of the meatus and tympanic membrane. Damage to the pinnal and tragal cartilages should be assiduously avoided. A sharp incision through cartilage usually does little harm but a puncture wound caused by the points of the retractor or burning with diathermy may encourage postoperative perichondritis. Haemostasis is obtained by diathermy and every effort must be made to prevent a postoperative haematoma developing beneath the endaural incision, for this too may encourage perichondritis.

The prehelical incision ought to be correctly placed parallel to the helix and not carried forwards into the parotid tissues, for this error often leads to an unacceptable scar.

On rare occasions a persistent petrosquamosal sinus runs across the lower part of the endaural incision to join the posterior auricular vein; if cut, this causes profuse bleeding.

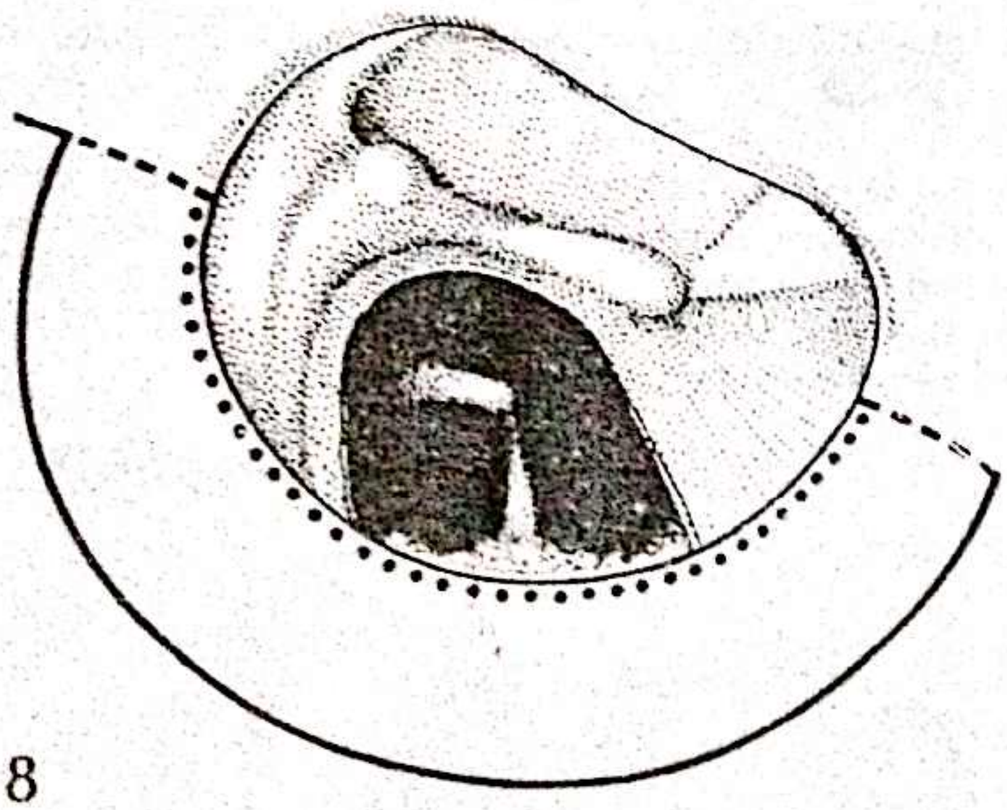


7

Preparation of meatal skin flaps

8

The only skin worth preserving to cover the facial ridge and to provide partial lining of the cavity is that of the deep meatus. The use of gland-bearing skin may produce a 'graft cholesteatoma' since the glands are lined by a modified squamous epithelium which, if damaged during elevation, may lead to an implant dermoid cyst or cholesteatoma within the cavity beneath the lining epithelium. Any gland-bearing skin is therefore excised before cutting and elevating the required inferiorly-based pedicled or tympanomeatal flap. The position of the incisions is shown by the dotted lines.



8

Inferiorly-based pedicled flap

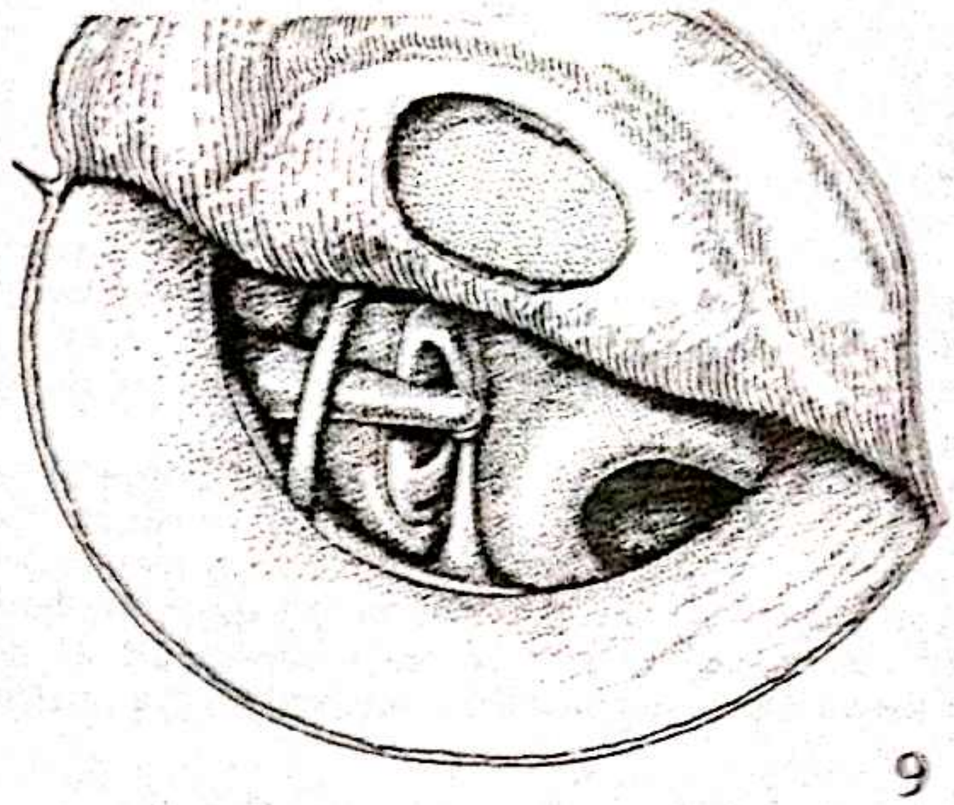
To obtain an inferiorly-based pedicled flap, which is more generally applicable, a meatal incision is made at 1 o'clock and carried outwards, and a second incision is made parallel to the annulus. This deep meatal skin flap is raised and turned downwards into the inferior meatus and protected.

A pedicled skin flap is not essential for satisfactory lining of the mastoid cavity and if the deep meatal skin is of poor quality all three meatal incisions should be made to remove the posterior meatal skin external to the annulus.

Tympanomeatal flap

9

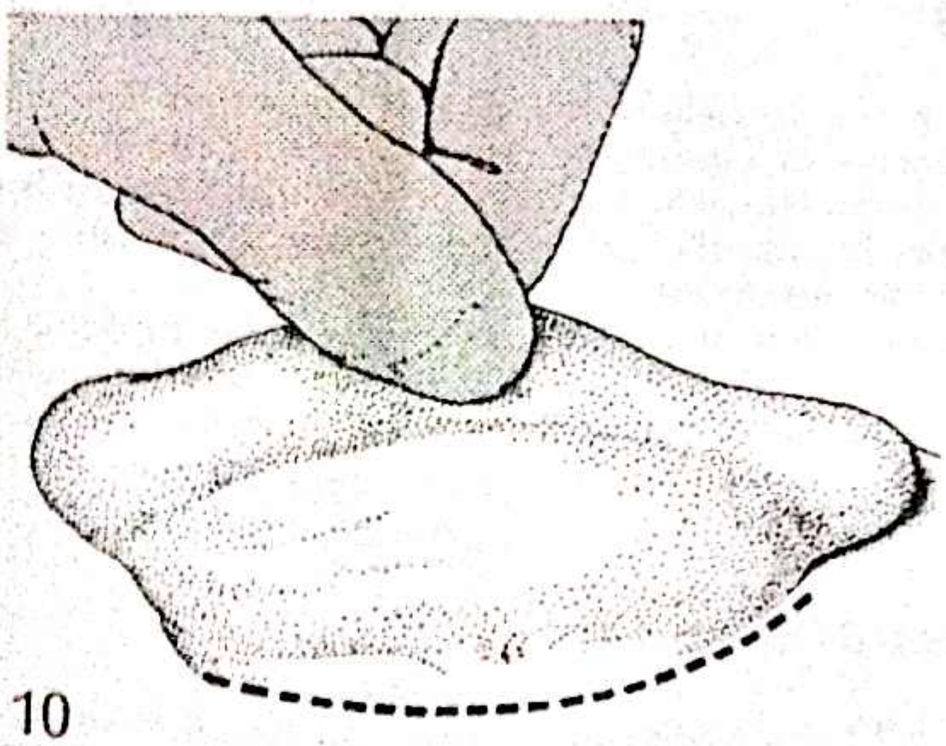
The tympanomeatal skin flap is outlined by meatal incisions made at 1 and 6 o'clock (on the right side) from the annulus outwards to the cut edge of the meatal cuff. In dissecting this type of flap care needs to be taken in elevating the skin from the tympanomastoid suture on the posterior wall and even more so in separating it from the tympanosquamous suture anterosuperiorly where the suture line is surmounted by the endomeatal spine. The annulus and the tympanic membrane are lifted in continuity with the meatal skin and hinged forwards on the handle of the malleus and tucked away in the anterior meatus, where they are covered by paraffin gauze, oiled silk or cotton wool for protection.



9

POSTAURAL INCISION

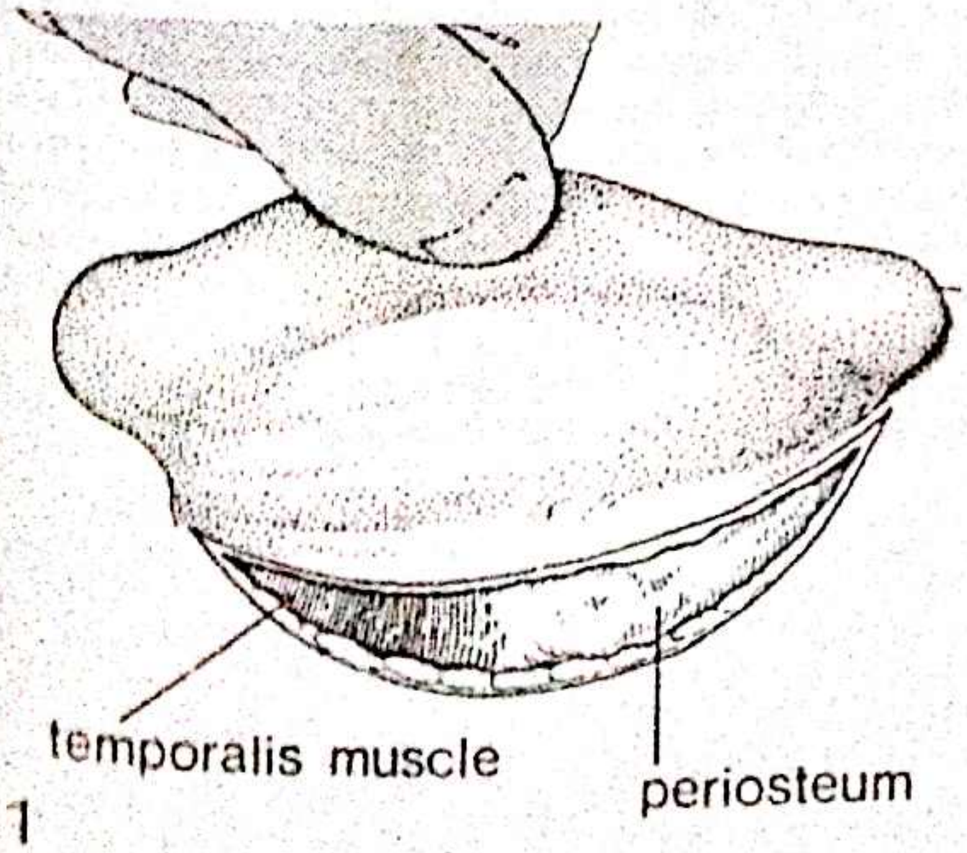
Similar exposure of the tympanic membrane and external auditory meatus, but with wider exposure of the mastoid cortex and easier access to the posterior fossa dura, lateral sinus and Trautmann's triangle, can be obtained through a postaural incision. However, access for tympanic exposure is not as direct as with the endaural incision, and manipulation and vision are slightly curtailed by the position of the pinna. The scar lying behind the ear is hidden from view.



10

10

The incision is made 5 mm behind the postauricular fold from the root of the zygoma above, parallel to the fold, to the mastoid tip below. Occasionally the lower part of the incision is curved backwards to expose the whole tip.



11

Exposure of temporalis

11

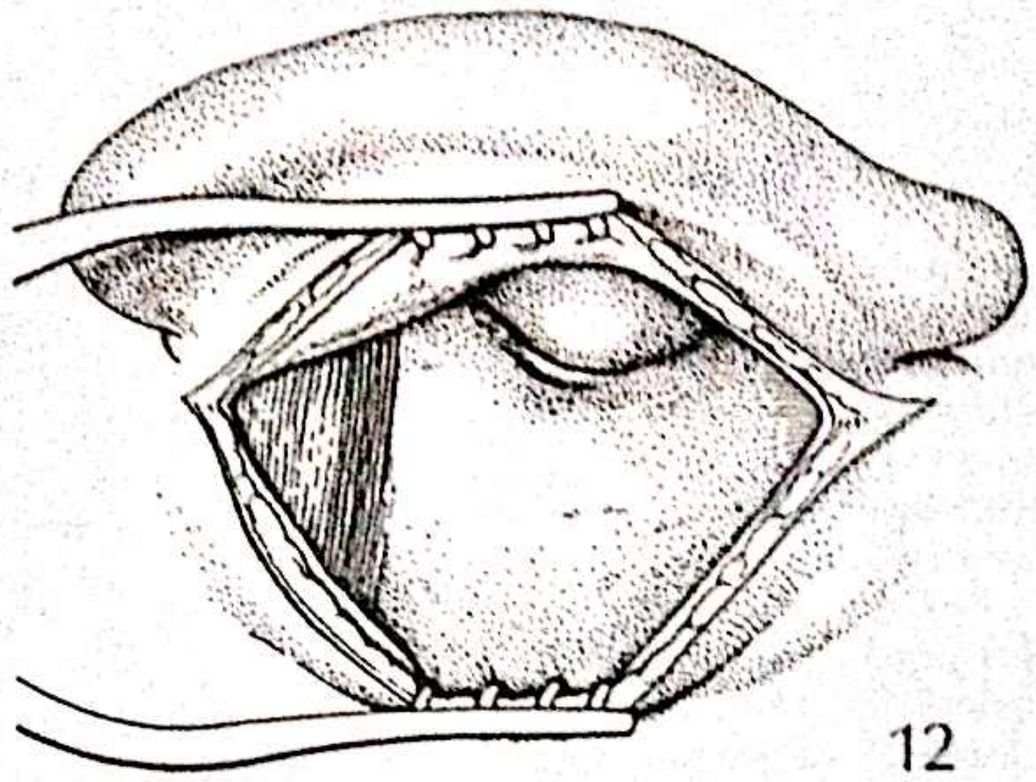
The incision is deepened to the level of the temporalis above and to the periosteum below.

Exposure of mastoid cortex

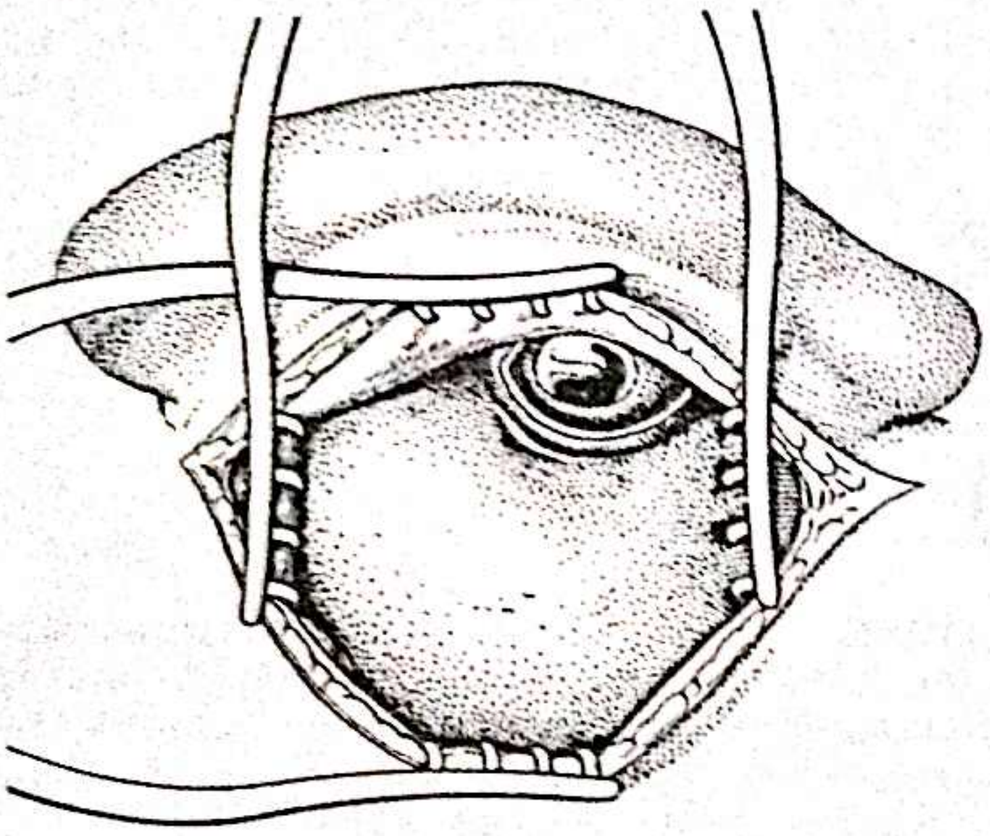
12

The wound edges are freed from the temporalis and periosteum and the self-retaining retractor is inserted. A fascial graft can now be cut, and if a large graft is required the upper edge of the wound can be retracted separately to increase exposure of the temporalis.

Another incision is then made at the lower edge of the temporalis and the muscle is elevated upwards. The periosteum is incised at the edge of the bony meatus and stripped backwards and downwards to expose the bony cortex. At the lower end of the wound, part of the insertion of the sternomastoid is scraped off the mastoid tip.



12



13

Exposure of meatus

13

The pinna is held forward and separated from the temporalis to expose the deep surface of the posterior wall meatal skin, which is then divided flush with the bony meatus to free the pinna and expose the meatus and tympanic membrane.

As it is essential to have a good view of the superior and anterior meatal walls, occasionally the posterior incision may need to be extended around the upper root of the pinna before inserting the self-retaining retractors.

Essential equipment

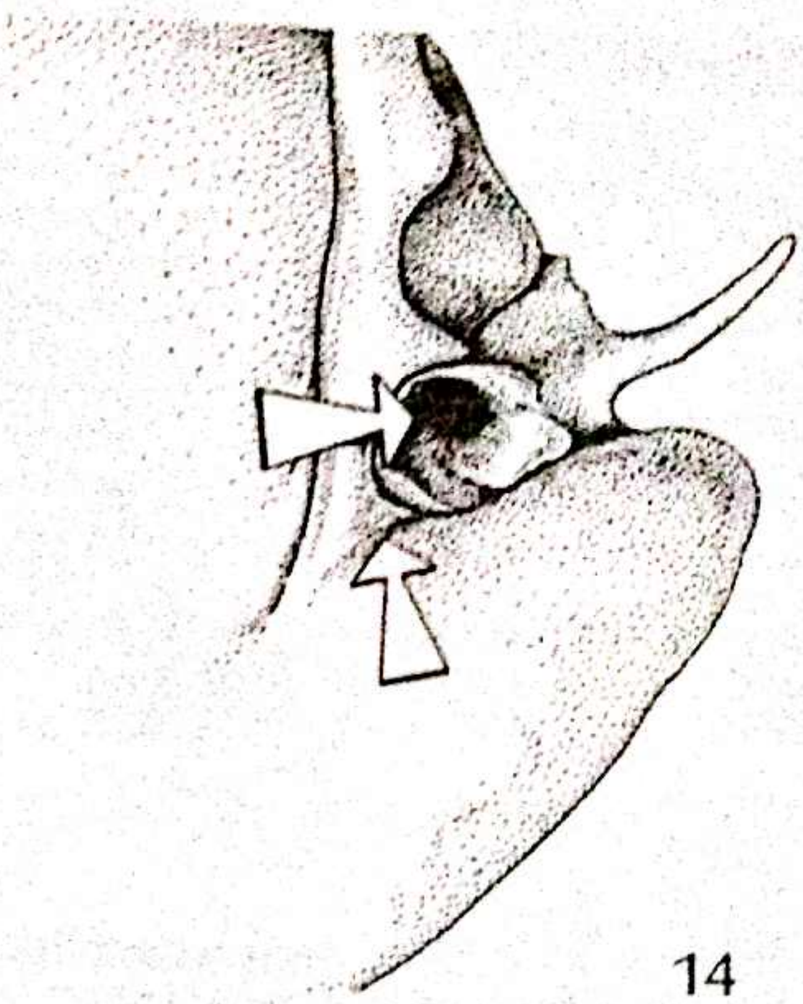
Although the crude bone work can be done with the naked eye with gouges or drills, for fine dissection and detailed bone work a Zeiss operating microscope is essential. An air drill or electrically driven motor with a minimum of 12 000 rev/min is required to drive the drill with either a straight or angled handpiece. A variety of cutting, polishing and diamond paste burrs from 6 to 0.5 mm should be available for use with the drill. For fine dissection a set of stapedectomy instruments is useful.

During surgery continuous or intermittent irrigation with Ringer's solution or isotonic (normal) saline is necessary to remove bone dust from the operative field, to prevent clogging of the cutting edges of the burr with bone dust, and to cool the bone itself.

Excavation of mastoid

14

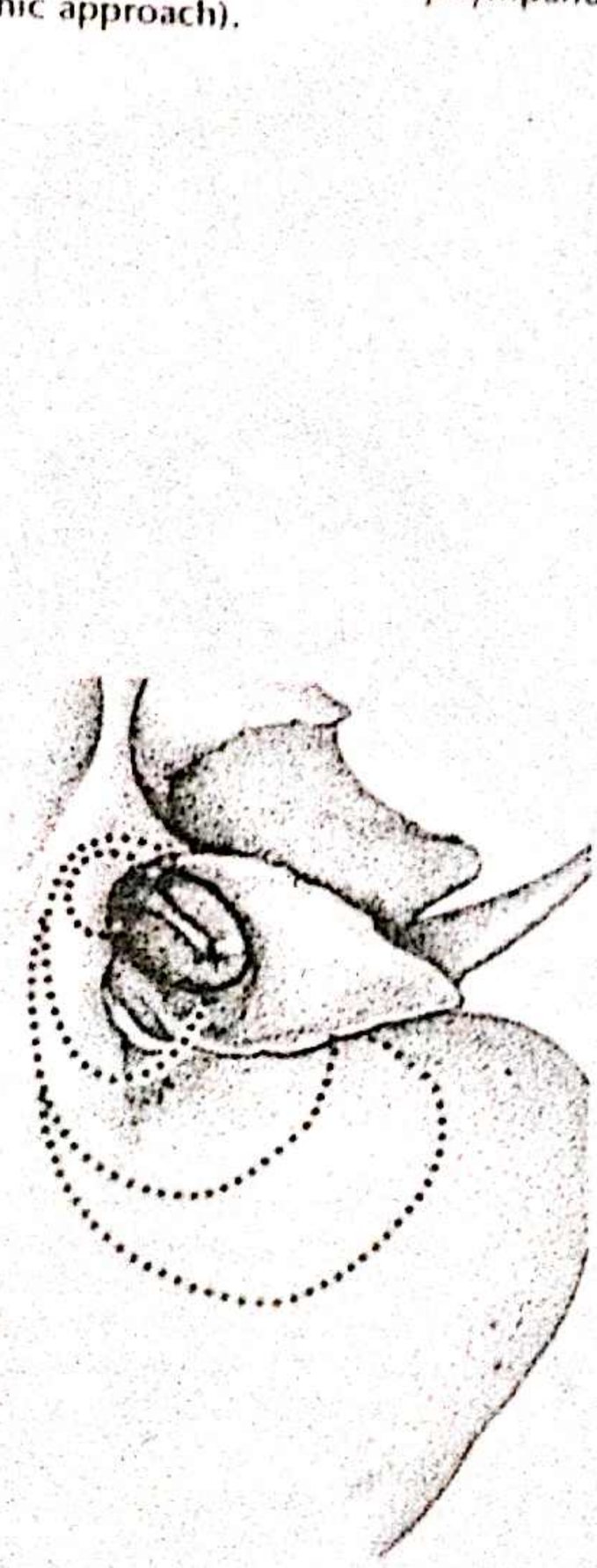
Once the mastoid has been exposed the middle ear cleft may be approached posteriorly through the mastoid towards the antrum (the transmastoid approach) or via the notch of Rivinis directly into the epitympanum (the transepitympanic approach).



14

Transepitympanic approach

15



15

This approach is usually combined with an endaural incision but can follow a postaural incision provided that the pinna can be retracted far enough forwards.

Magnification with an operating microscope and familiarity with drill techniques are desirable, if not essential, for a safe and accurate surgical approach.

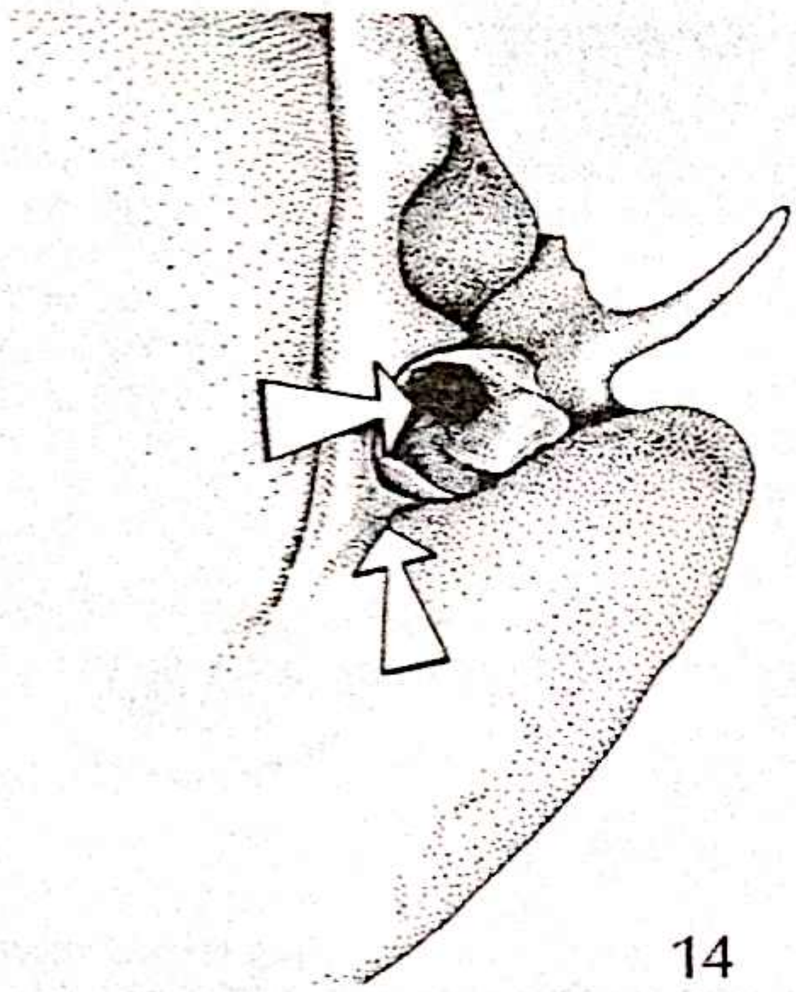
The transepitympanic route gives direct access to, and an excellent view of, the epitympanum and tympanum, and as surgical landmarks are soon identified orientation throughout the operation is easier to maintain. Consequently, the posterior and superior meatal walls can be confidently removed as the disease is followed from its origin in the tympanum to the mastoid, so enabling the bony removal to be limited or extended as required and giving ready access to the sinus tympani when necessary. Thus, what is begun as an epitympanotomy may be extended to an epitympano- or tympanomastoidectomy.

As cholesteatoma is usually associated with a sclerotic or small-celled mastoid, an overhanging middle fossa dura or forwardly placed lateral sinus is not uncommon, and this direct approach to the disease has the immense advantage of not being obstructed by these anatomical variations. Furthermore, as cholesteatoma is locally destructive, early orientation is a great advantage.

Excavation of mastoid

14

Once the mastoid has been exposed the middle ear cleft may be approached posteriorly through the mastoid towards the antrum (the transmastoid approach) or via the notch of Rivinis directly into the epitympanum (the transepitympanic approach).



14

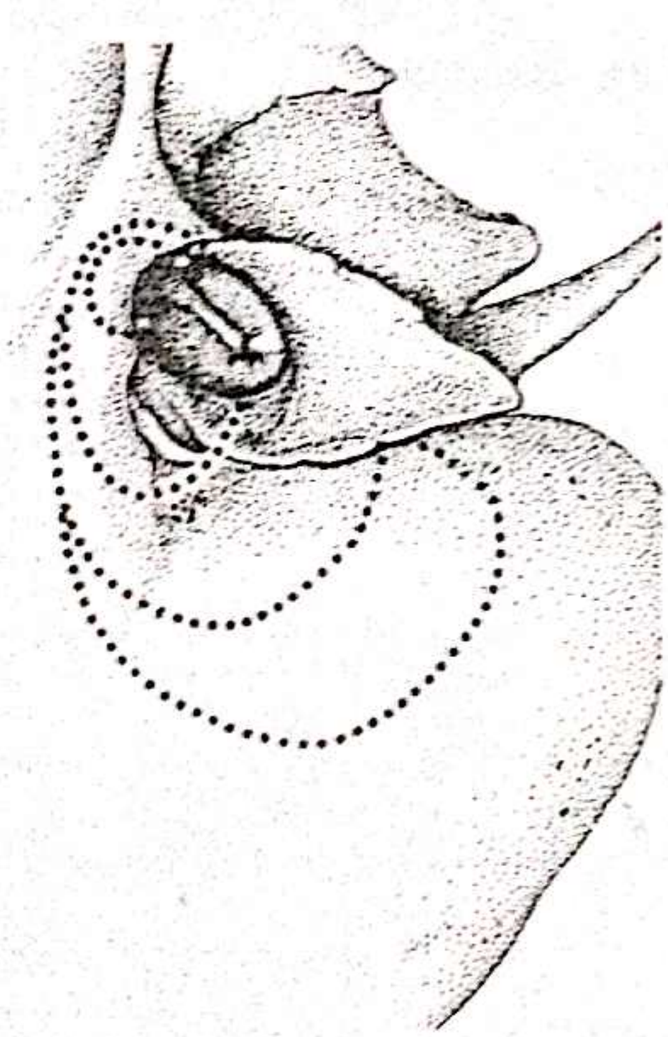
Transepitympanic approach

15

This approach is usually combined with an endaural incision but can follow a postaural incision provided that the pinna can be retracted far enough forwards.

Magnification with an operating microscope and familiarity with drill techniques are desirable, if not essential, for a safe and accurate surgical approach.

The transepitympanic route gives direct access to, and an excellent view of, the epitympanum and tympanum, and as surgical landmarks are soon identified orientation throughout the operation is easier to maintain. Consequently, the posterior and superior meatal walls can be confidently removed as the disease is followed from its origin in the tympanum to the mastoid, so enabling the bony removal to be limited or extended as required and giving ready access to the sinus tympani when necessary. Thus, what is begun as an epitympanotomy may be extended to an epitympano- or tympanomastoidectomy.



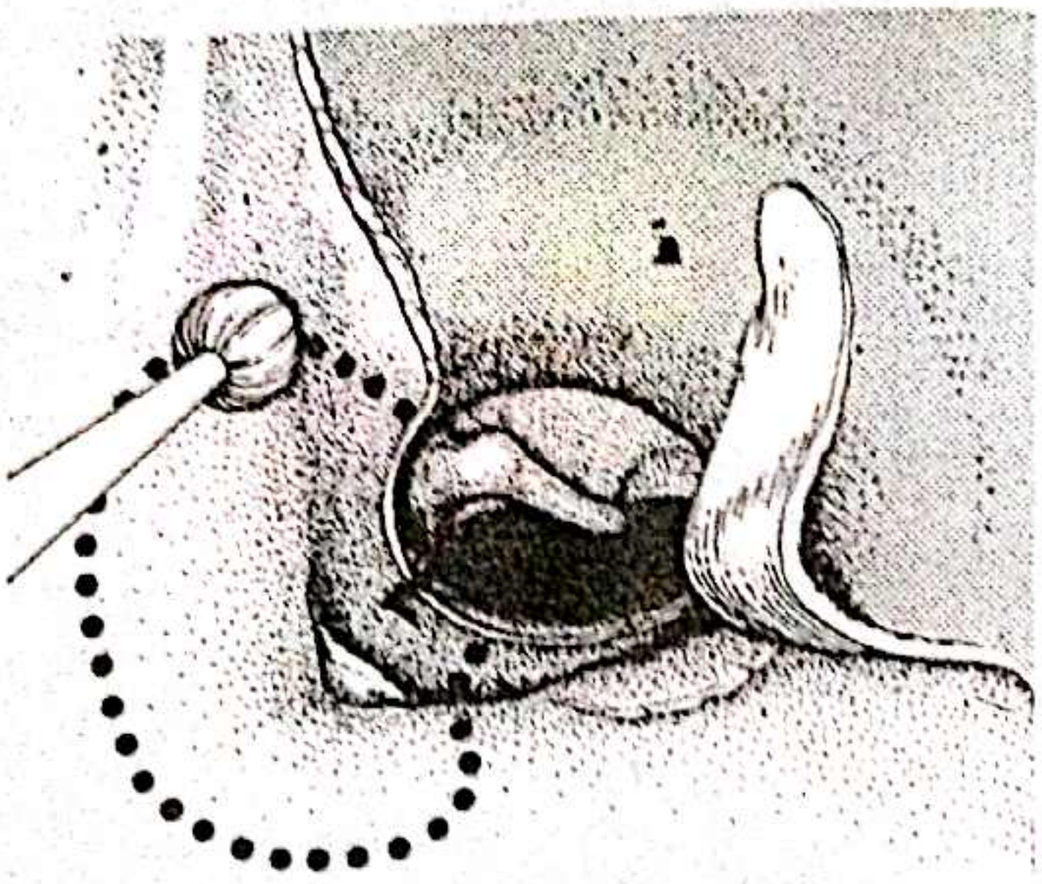
15

As cholesteatoma is usually associated with a sclerotic or small-celled mastoid, an overhanging middle fossa dura or forwardly placed lateral sinus is not uncommon, and this direct approach to the disease has the immense advantage of not being obstructed by these anatomical variations. Furthermore, as cholesteatoma is locally destructive, early orientation is a great advantage.

Epitympanotomy (atticotomy)

This operation has a very limited application and is usually only the first stage of an epitympanomastoidectomy. It is of value when the cholesteatoma is small, confined to the epitympanum and readily excisable together with its covering mucous membrane, and when the remaining mucous membrane is simply thickened. Excision of the lesion is most certain when the cholesteatoma lies external to the ossicular chain or when the lesion can be excised together with the head of malleus and incus. Less certainty exists if the cholesteatoma extends into the aditus or has eroded bone medially or anteriorly, or if it has bulged downwards into the anterior part of the tympanum.

16

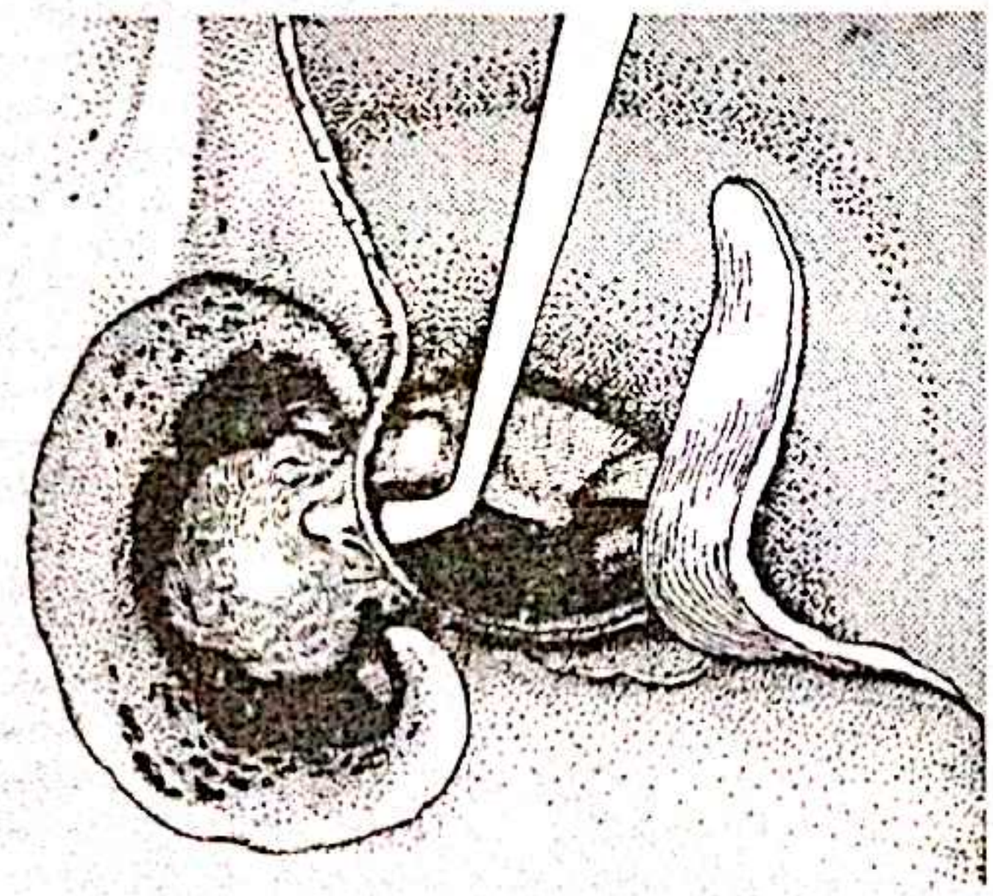


16

The first step is to enlarge the bony meatus with a 3–4 mm cutting burr to remove bone from the posterior and superior walls of the external meatus at the isthmus, and including Henle's spine, so taking away the overhang from the outer bend and straightening the meatus before removing the outer epitympanic wall with a drill or curette.

Exposure of epitympanum

17



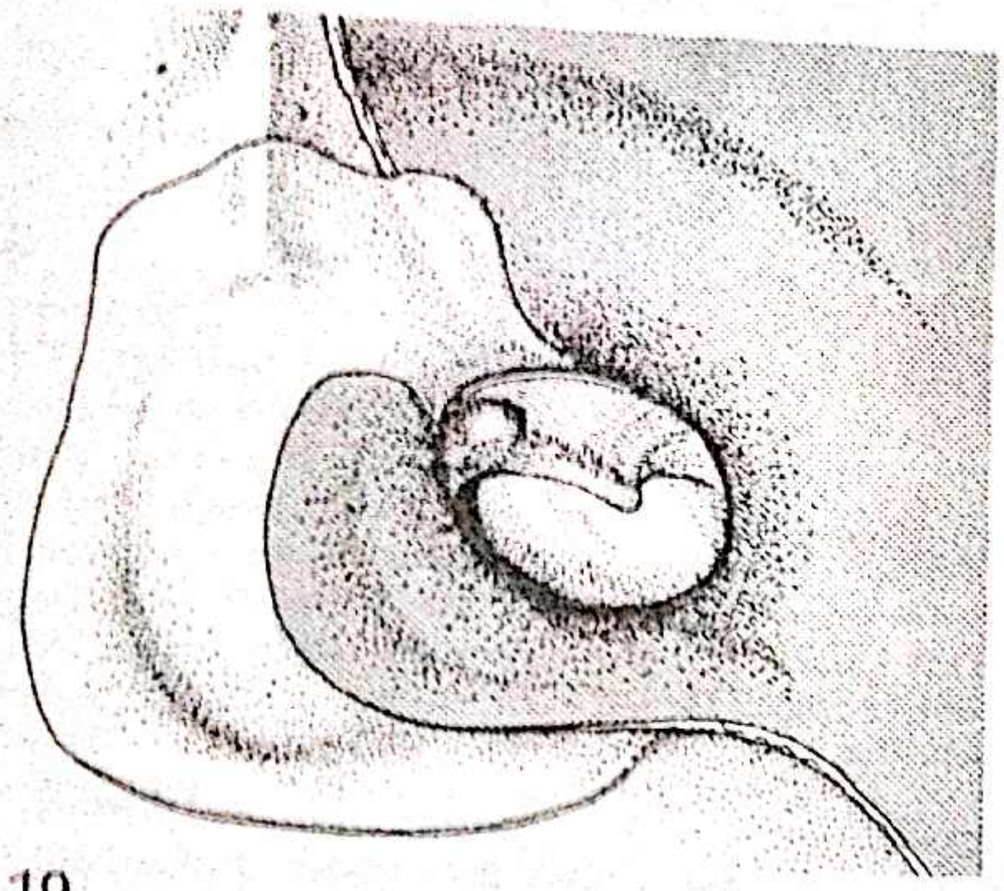
17

The attic opening or erosion is enlarged with a 2 mm cutting burr and small curettes, working from within outwards, to expose the cholesteatoma fully and when necessary up to and flush with the tegmen above and backwards towards the aditus. Anteriorly bone removal should be extended either beyond the limit of the cholesteatoma or flush with the anterior epitympanic wall. In removing this bone great care must be exercised not to make contact with the ossicular chain for fear of transmitting a massive displacement through an intact incudostapedial joint to the vestibule and thereby endangering the hearing. There is no risk if the long process of the incus is defective, but if there is doubt the annulus and posterior segment of the drum should be elevated and the incudostapedial joint inspected and, if intact, divided before continuing removal of the outer epitympanic wall. An equally safe method of starting bone removal from the outer epitympanic wall is to use a curette until a satisfactory view can be obtained. A 2 mm diamond paste burr may be preferred to a cutting burr.

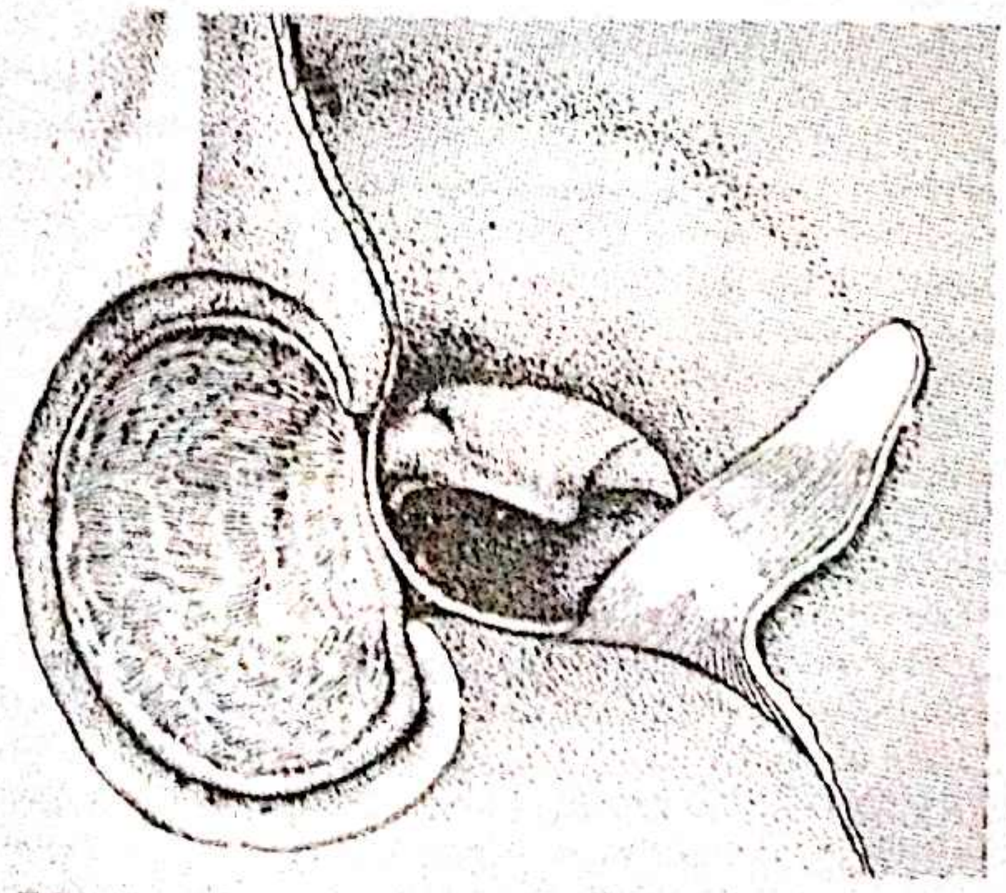
18

Once the cholesteatoma is fully exposed it can be carefully removed in one piece with fine excavators and needles (as in Hough's stapedectomy set), leaving the ossicular chain intact or removing the head of malleus and body of incus if they are invested by cholesteatoma matrix, to gain access to the deeper parts of the epitympanum. All the matrix must be removed.

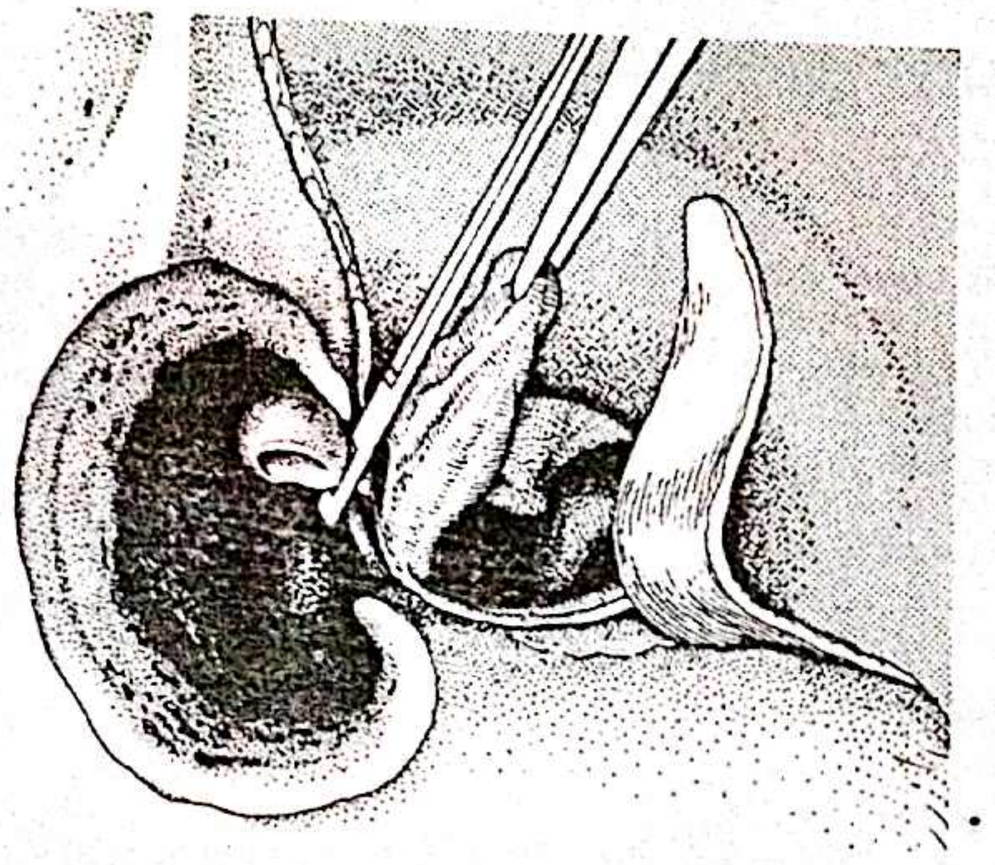
If no mucinous discharge is aspirated from the aditus and the residual mucous membrane is healthy no further bone removal will be needed and the epitympanic defect is repaired.



19



20



18

Repair with fascial graft

19

Provided bony removal was limited and the cholesteatoma small, a fascial graft alone can be placed over the bony defect and tucked underneath the meatal skin antero-superiorly and covered by the inferiorly-based pedicle flap posteriorly. This fascia can also be shaped to cover a posterosuperior drum defect either as an onlay or underlay graft, as in a myringoplasty.

Repair with cartilage or cortical bone

20

With a larger bony defect a shallow shelf can be cut into the bone at the tympanic level to accommodate a shaped piece of preserved cartilage or thinned cortical bone taken from the mastoid, on top of which a suitably cut fascial graft can be laid to repair a tympanic membrane perforation in the onlay position. This cartilage or bony plate prevents the fascial graft from collapsing into the epitympanum to form a pouch. The grafts are held in position with Sterispon, the endaural wound is sutured and a bismuth iodoform paraffin paste (BIPP) pack 5–7 cm long is inserted into the external meatus to hold the posterior part of the meatal portion of the endaural incision against the bony meatal wall.

The sutures are removed on the 5th postoperative day together with the BIPP pack but the Sterispon is left untouched for 6 weeks.

Ossicular defects, including those deliberately created, can be repaired by transposition of a homograft or autograft incus either at the time of surgery or 6–12 months later as a second-stage procedure.

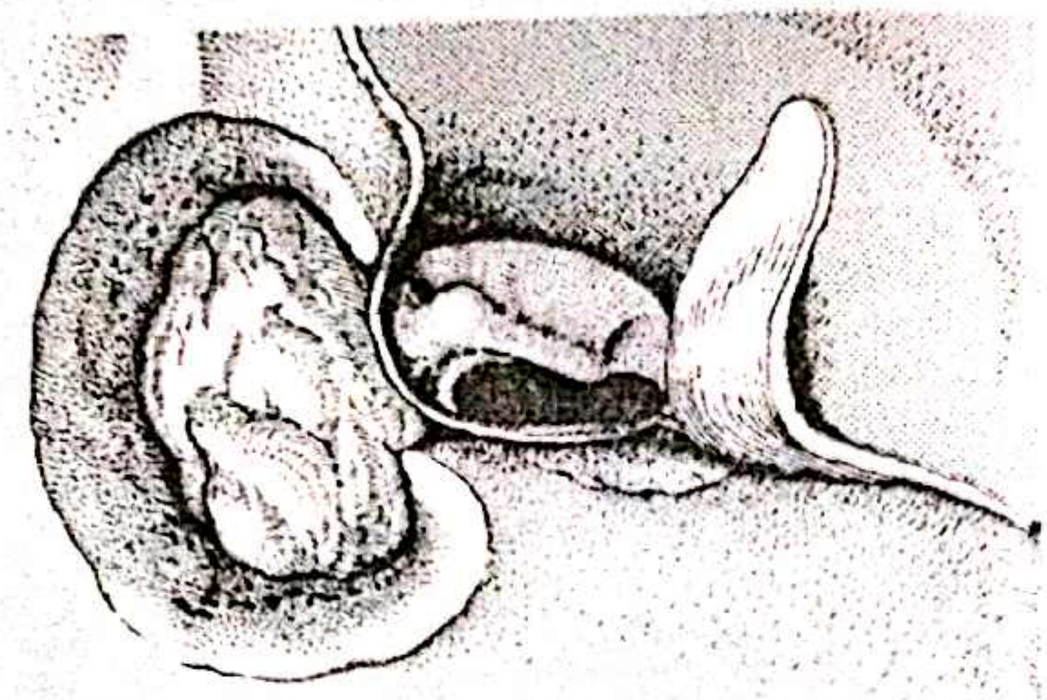
Epitympanomastoidectomy (attico-antrostomy)

This operation applies when the cholesteatoma extends into and beyond the aditus and antrum but does not extend into the mesotympanum below the level of the stapes and does not involve the lower part of the sinus tympani. The mucous membrane lining the mesotympanum and hypotympanum should be normal or simply thickened, not granular or polypoid.

The transepitympanic route

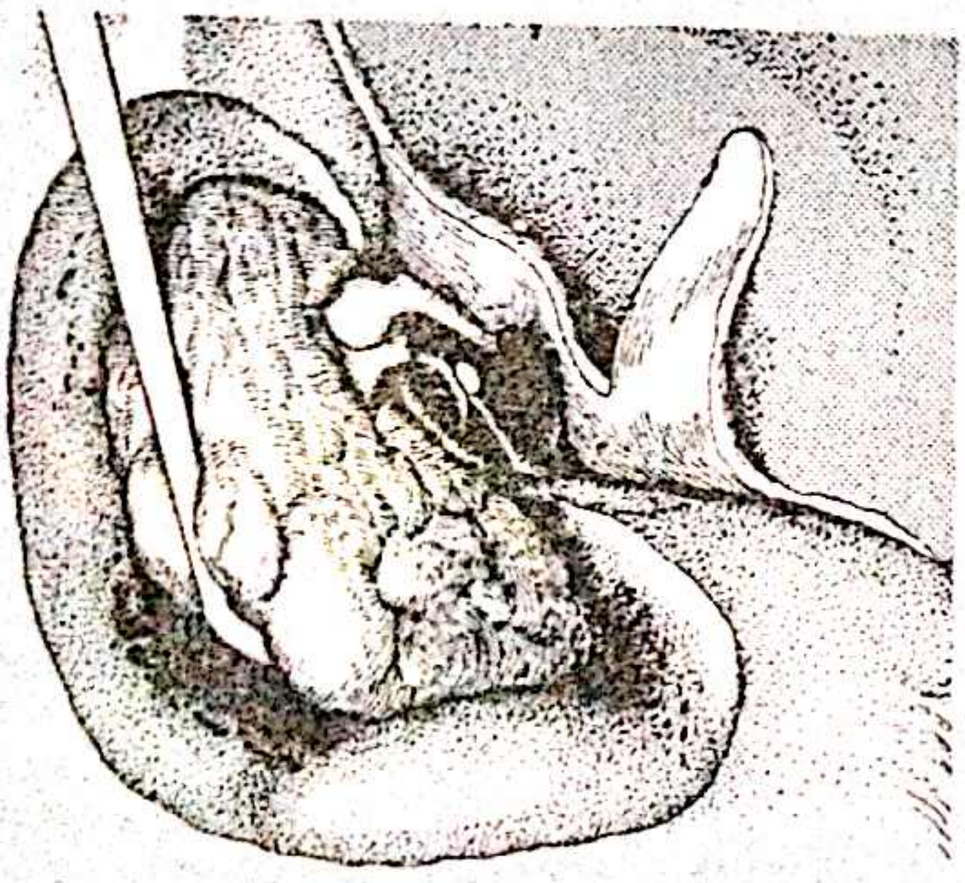
21

The first steps of the exposure are the same as in an epitympanotomy (*see illustration 16*) but, as the cholesteatoma is found to extend backwards into the antrum beyond the limits of the exposure, the mastoid cortex must be removed.



21

Excavation of mastoid



22

22

A 4–5 mm cutting burr is used in a circular pattern as if enlarging the meatus until the whole cholesteatoma is uncapped. As the epitympanum has been opened the level of the body of the incus can easily be checked, and the bone of the posterior meatal wall can be lowered during the uncapping to the level of this plane without endangering the facial canal.

A burr should always be used working from within outwards, away from the facial canal, and the working depth should be frequently assessed. If the body of the incus is not present the position of the facial canal can be ascertained either by lifting the lower edge of the epitympanic portion of the cholesteatoma to see it lying within its canal or by seeing the stapes remnant. Once its approximate position is known the posterior meatal wall can be removed to a suitably modified depth with increasing confidence, but it is essential to continually recheck the nerve's position. A facial canal or nerve if seen can always be avoided, whereas it may well be damaged if not recognized. At this stage of the operation the posterior meatal wall need only be lowered to a level which provides adequate exposure of the cholesteatoma, the final lowering of the facial ridge being left to a later stage when the facial canal itself can be easily seen.

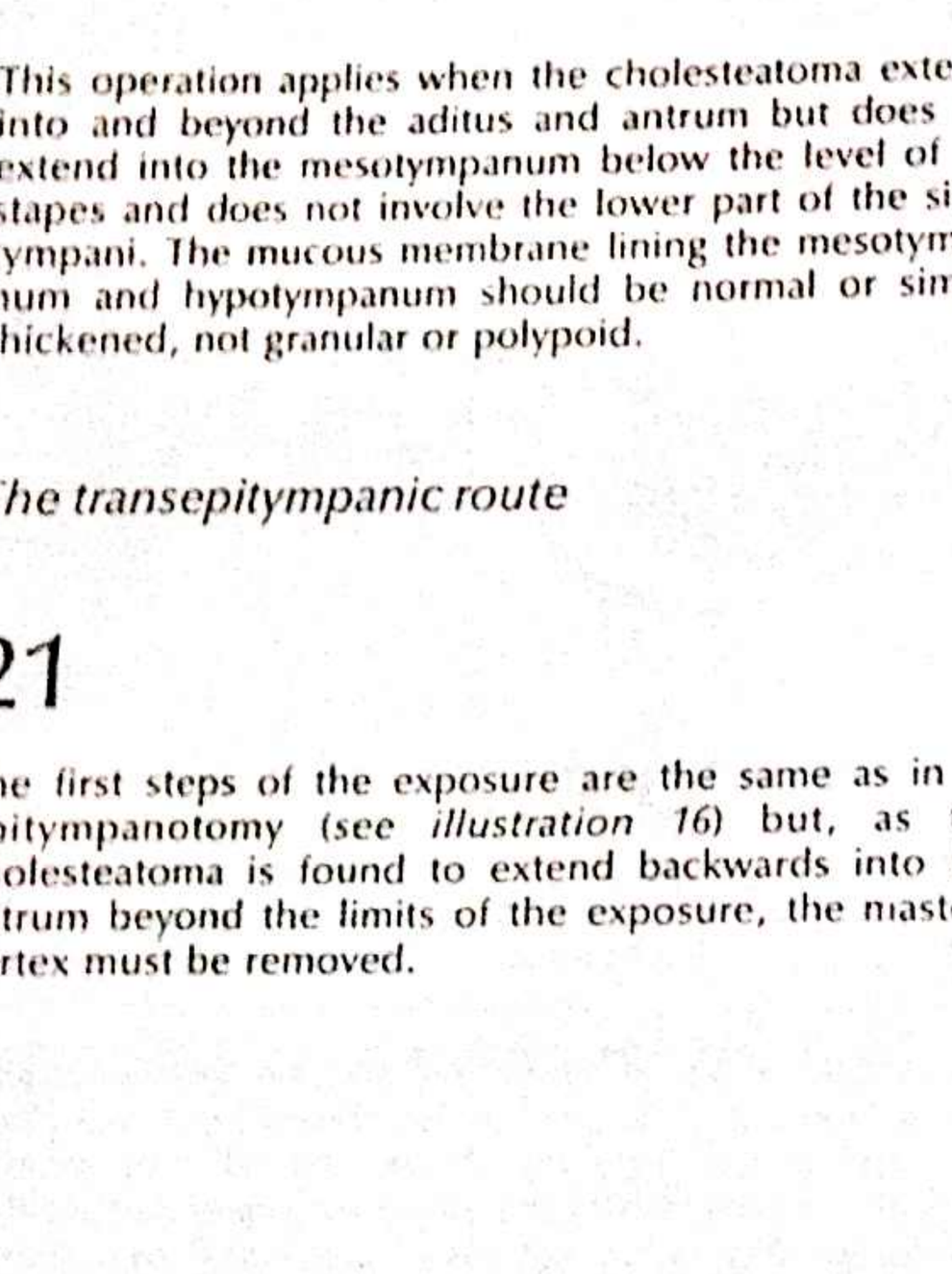
Epitympanomastoidectomy (attico-antrostomy)

This operation applies when the cholesteatoma extends into and beyond the aditus and antrum but does not extend into the mesotympanum below the level of the stapes and does not involve the lower part of the sinus tympani. The mucous membrane lining the mesotympanum and hypotympanum should be normal or simply thickened, not granular or polypoid.

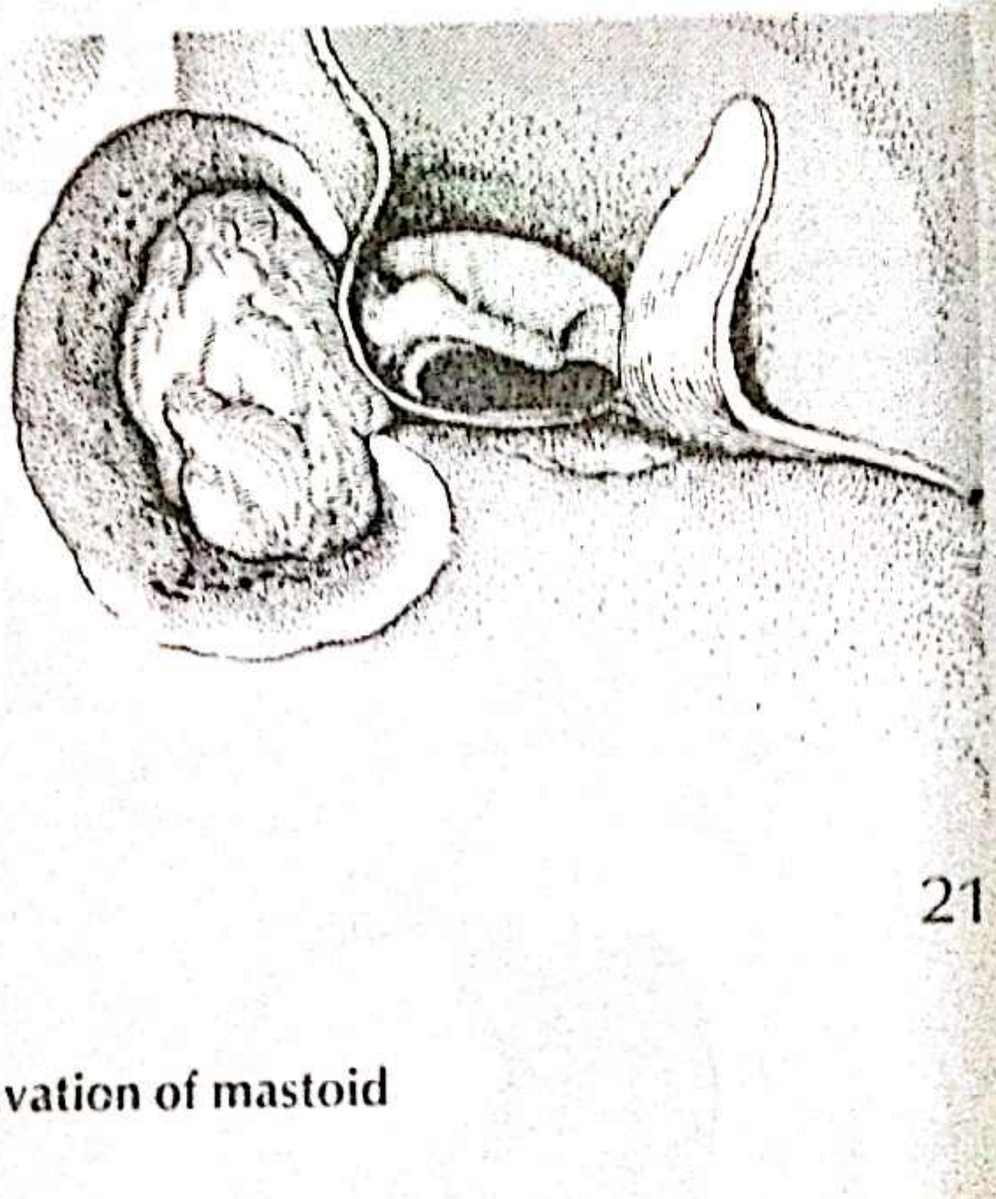
The transepitympanic route

21

The first steps of the exposure are the same as in an epitympanotomy (*see illustration 16*) but, as the cholesteatoma is found to extend backwards into the antrum beyond the limits of the exposure, the mastoid cortex must be removed.



22



21

Excavation of mastoid

22

A 4–5 mm cutting burr is used in a circular pattern as if enlarging the meatus until the whole cholesteatoma is uncapped. As the epitympanum has been opened the level of the body of the incus can easily be checked, and the bone of the posterior meatal wall can be lowered during the uncapping to the level of this plane without endangering the facial canal.

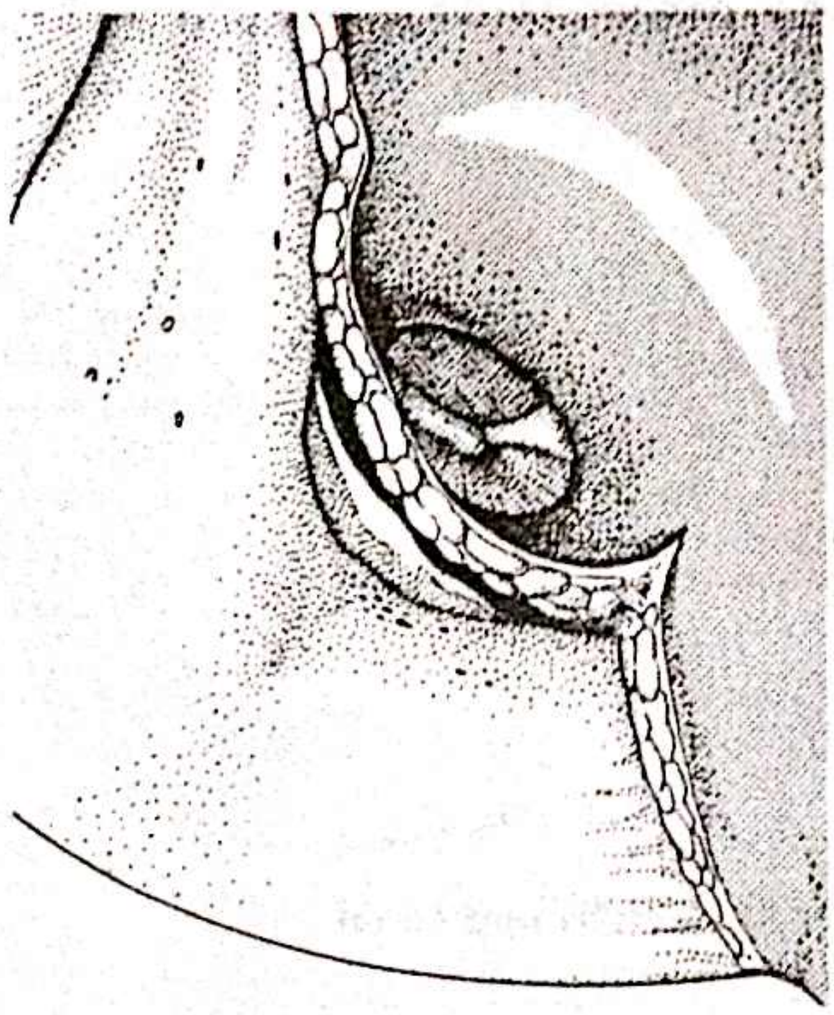
A burr should always be used working from within outwards, away from the facial canal, and the working depth should be frequently assessed. If the body of the incus is not present the position of the facial canal can be ascertained either by lifting the lower edge of the epitympanic portion of the cholesteatoma to see it lying within its canal or by seeing the stapes remnant. Once its approximate position is known the posterior meatal wall can be removed to a suitably modified depth with increasing confidence, but it is essential to continually recheck the nerve's position. A facial canal or nerve if seen can always be avoided, whereas it may well be damaged if not recognized. At this stage of the operation the posterior meatal wall need only be lowered to a level which provides adequate exposure of the cholesteatoma, the final lowering of the facial ridge being left to a later stage when the facial canal itself can be easily seen.

The transmastoid route

This route is the usual approach to the antrum after a postaural incision but it can equally well be used through an endaural incision.

23

The landmarks of the antrum are Henle's spine and MacEwan's triangle. If the spine is absent, the numerous small foramina formed by perforating vessels within MacEwan's triangle are a useful guide. A low middle fossa dura or forward lateral sinus will limit access by this route. Preoperative radiographs will forewarn the surgeon of these impending difficulties and the need for an alternative approach.

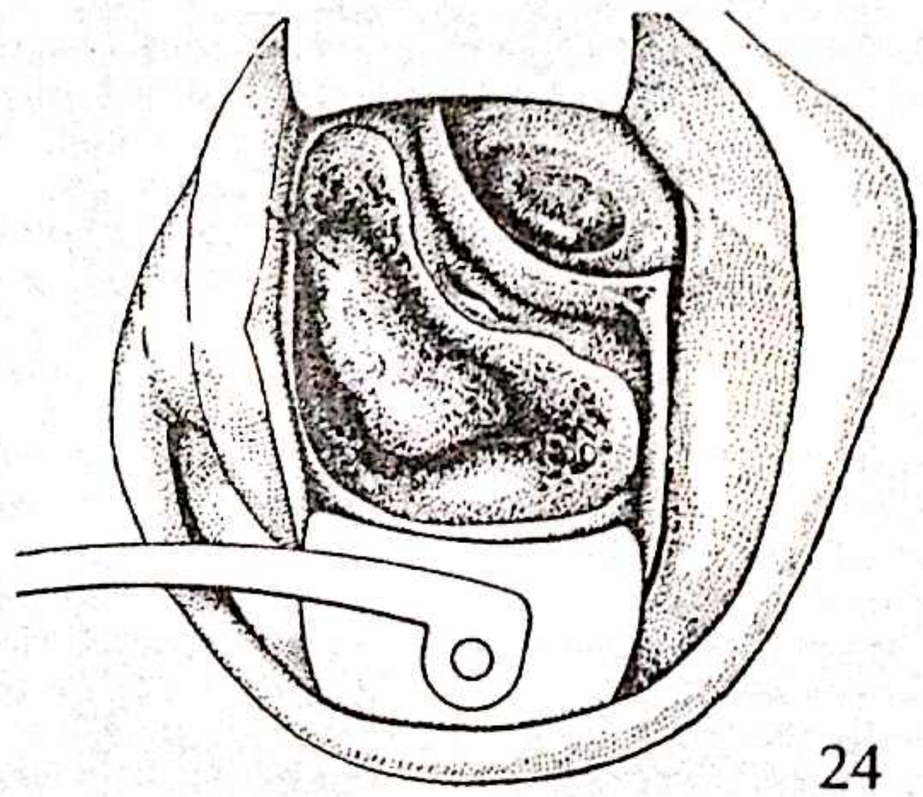


23

Opening of antrum

24

Using a large round cutting burr 5–6 mm in diameter the bone above and behind the external auditory meatus is gradually excavated. The initial bone removal should extend from above the centre of the meatus backwards to just below the level of the posterior root of the zygoma for approximately 1–1.5 cm and down towards the mastoid tip. The posterior meatal wall should be kept intact to protect the meatal skin. The excavation is gradually deepened, centring over the antrum, until either the cholesteatoma is exposed or the antrum entered.



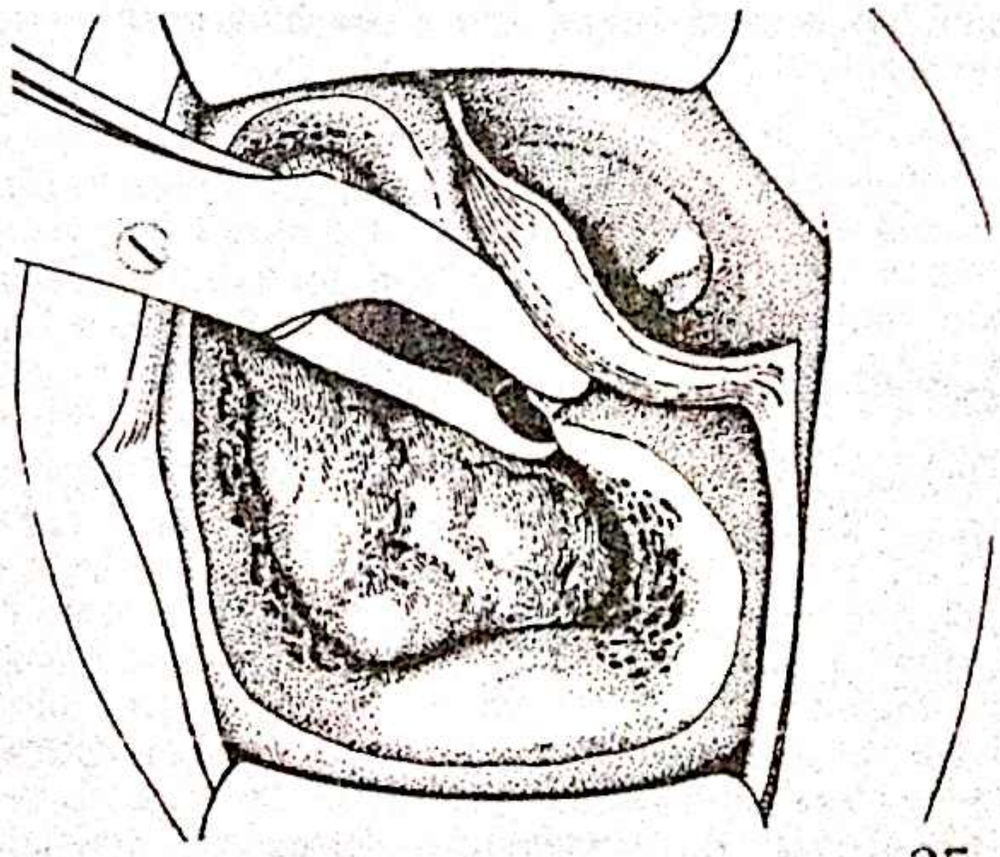
24

Excavation of mastoid and removal of 'bridge'

25

The walls of the excavation should be bevelled and a careful watch maintained in case the middle fossa dura or lateral sinus is exposed during enlargement of the cavity to expose the whole surface of the cholesteatoma. Bone removal must be carried forwards above the meatus into the aditus and epitympanum using a 2–3 mm burr from within outwards in order to avoid damage to the underlying structures. With opening of the aditus and epitympanum the top of the body of the incus and head of the malleus can be seen. During the whole process of excavation the bony posterior meatal wall has been thinned, but kept intact, and a 'bridge' of bone has been created, formed by the posterosuperior meatal wall overlying the ossicles. This 'bridge' and thinned posterior meatal wall can then be removed by rongeurs or diamond burrs to lay bare the whole cavity and its cholesteatoma, as has been described for the transepitympanic approach. The meatal skin flaps are now fashioned.

With increasing familiarity the transmastoid and transepitympanic routes can be combined and adapted to the anatomical requirements of each individual case.

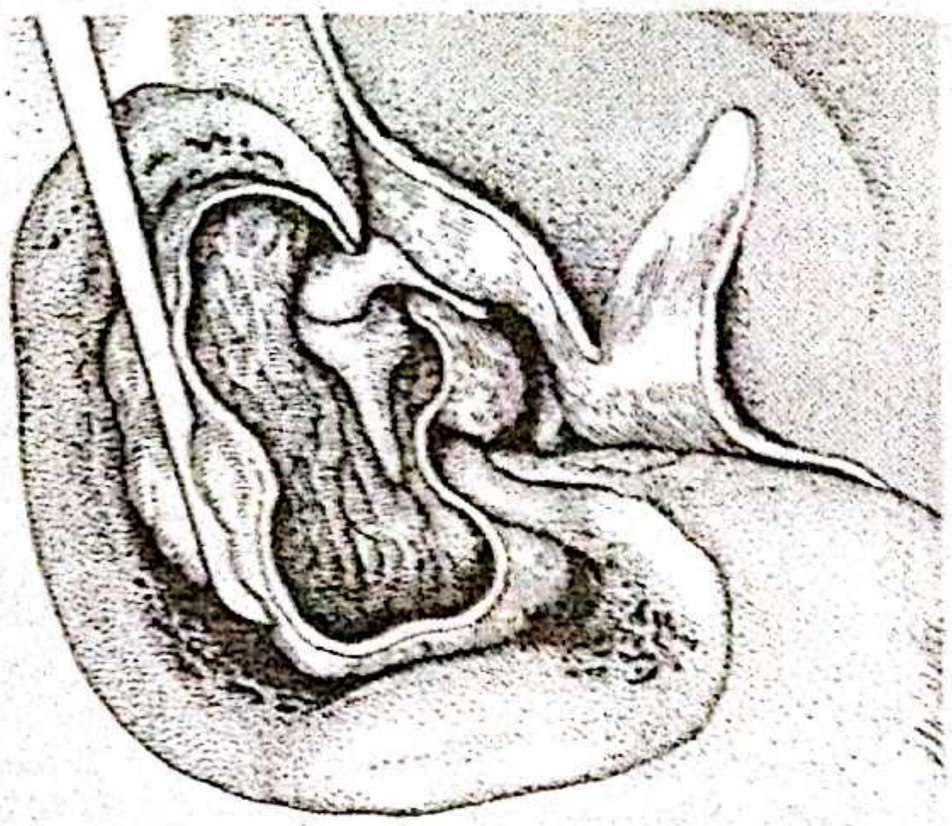


25

Exposure of cholesteatoma

26

Once the disease is uncovered, the margin of the cholesteatoma can be elevated (to assess the depth of the erosion) and gently freed from the underlying bone or tissue and displaced towards the external auditory meatus. A bulky cholesteatomatous mass may impede the view and often needs to be opened so that its contents can be partly aspirated to facilitate further dissection.



26

Exposure of semicircular canal

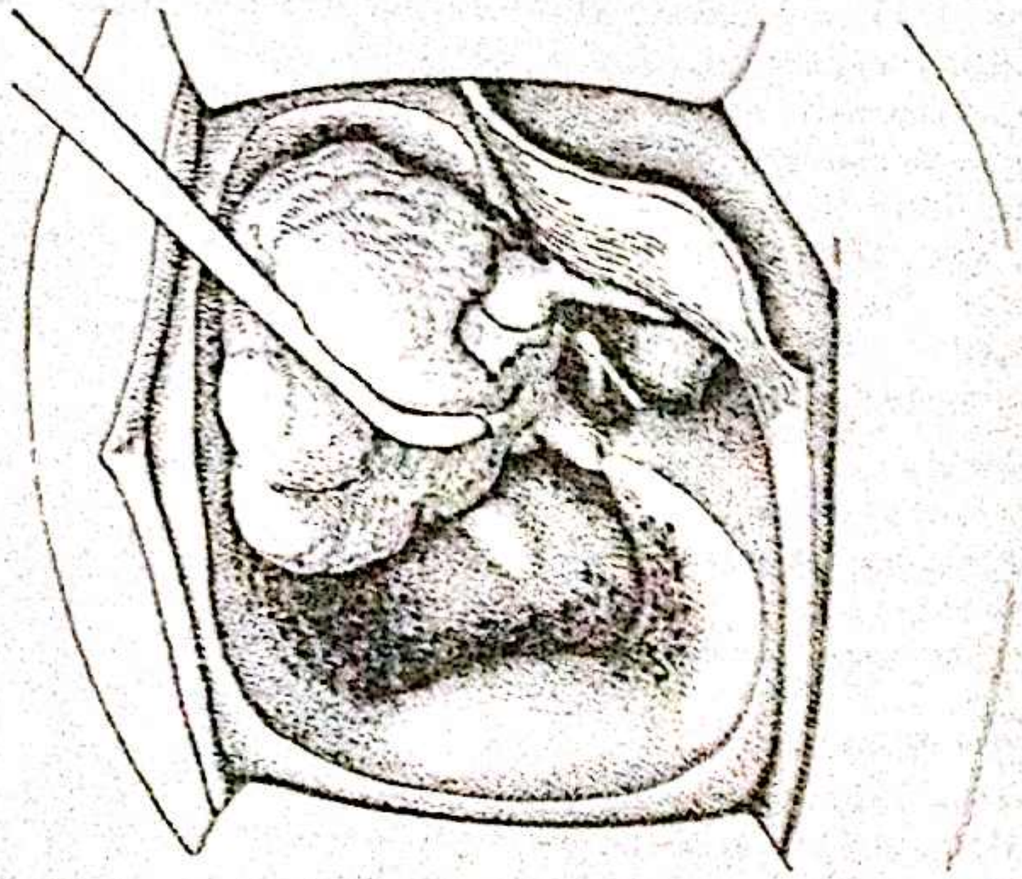
27

The deeper part of the matrix can be readily elevated forwards from the mastoid cavity to expose the lateral semicircular canal. With this landmark established, the cavity behind it can be cleared with confidence.

Particularly in children, a very cellular mastoid may be found, with cholesteatoma filling many of the cells. All of this must be burred away and the matrix carefully dissected out, even if these cells extend into the depths of Trautmann's triangle or posterior to the lateral sinus.

Frequently the mastoid tip cells and periantral cells, even if not involved by cholesteatoma, are filled with thickened and granular mucosa similar to that seen in cholesterol granuloma; these cells too must be cleared. Cell clearance should be carried back to the lateral sinus plate behind and to the tegmen above, and particular care should be taken to clear those of the sinodural angle.

Fortunately, because cholesteatoma is associated with a poorly pneumatized mastoid, such a deliberate extensive removal of bone is usually unnecessary and removal is carried down to healthy, relatively sclerotic bone. The healthy bone is smoothed with a polishing or diamond paste burr.



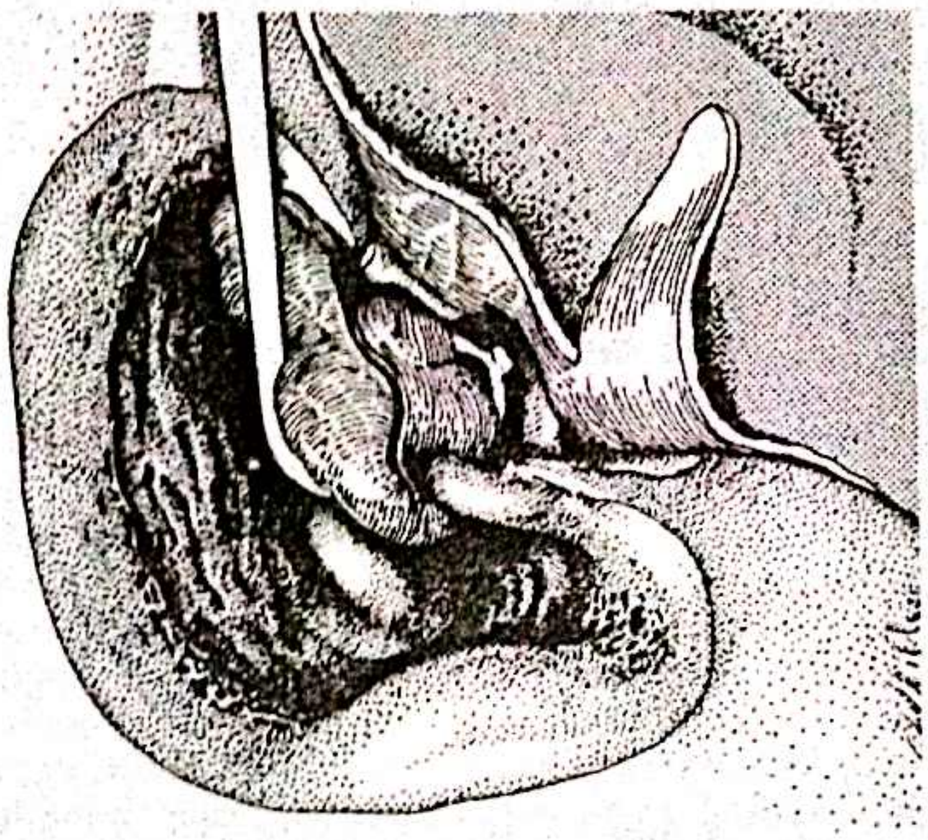
27

Exposure of epitympanum

Having exposed the posterior part of the lateral semicircular canal, the integrity of the long process of the incus is checked. If it is defective, the remainder is removed. If intact, it must be decided whether to keep it. It can only be safely preserved if the cholesteatoma matrix can be dissected off it and the malleus without leaving any matrix on the deeper surface or within the anterior epitympanum. Usually it is necessary to remove the incus, even if intact, to reach the remaining cholesteatoma. Similarly, the head of the malleus may need to be removed for access to the anterior epitympanum. Even if the head of the malleus can be preserved there is little point in doing so unless there is wide clearance from the walls of the epitympanum, for it frequently becomes ankylosed to the walls later, thus preventing free movement of the tympanic membrane – a deterrent to successful reconstruction of a functioning ossicular chain.

28

After removing the ossicular mass from the epitympanum the matrix is very gently elevated from the surface of the semicircular canal while carefully inspecting and assessing the integrity of the bony canal. Should a fistula be present, gentle elevation and teasing of the matrix will usually expose an intact membranous labyrinth. However, should the surgeon feel that further interference would endanger the integrity of the membranous labyrinth, he would be wise to leave the matrix over the fistula and accept that he was unable to excise it all. If the patient had total loss of hearing before surgery there is no point in leaving the matrix; it must be removed and followed into the vestibule if need be. Unless the patient had a 'dead' ear preoperatively, at no time should suction be used close to a semicircular canal fistula, for this is one of the surest means of damaging an exposed membranous labyrinth.



28

Exposure of facial canal

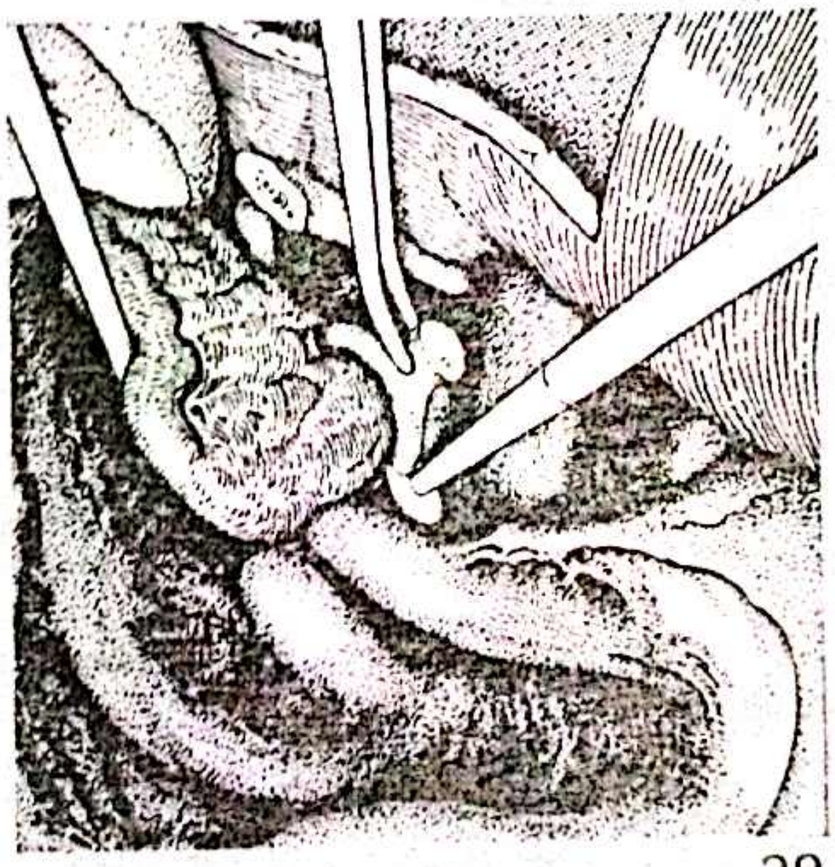
29

Continued elevation of the matrix reveals the facial canal as a whiter strip of bone with its associated vessel running above the oval window. Gentle manipulation is essential as a dehiscence in the canal wall will leave the nerve itself exposed over a variable distance within the horizontal part of the canal. Commonly a lateral semicircular canal fistula is associated with an exposed nerve and its presence can be regarded as a useful warning of the dangers ahead. Occasionally a cholesteatoma which has invaded the vestibule through the dome of the lateral semicircular canal erupts through the oval window, leaving the bare facial nerve stretched across a bony gap, with the nerve completely invested by a cholesteatoma matrix. In these circumstances the cholesteatoma cannot be completely excised.

As suction may cause lethal damage to the membranous labyrinth or serious injury to the facial nerve, only gentle suction through fine tubes should be permitted close to them. If powerful suction is needed to remove bone chips, intermittent or continuous irrigation should be used to wash these away from the important structures first so that their aspiration can be done from a safe distance.

Once the facial canal is identified the remaining bone of the posterior meatal wall (i.e. the facial ridge) can be confidently lowered almost to the level of the vertical plane of the nerve, widely opening the upper part of the facial recess and fully exposing the pyramid, stapes remnants and chorda tympani.

As the epitympanomastoidectomy is only concerned with disease extending down to the level of the oval



29

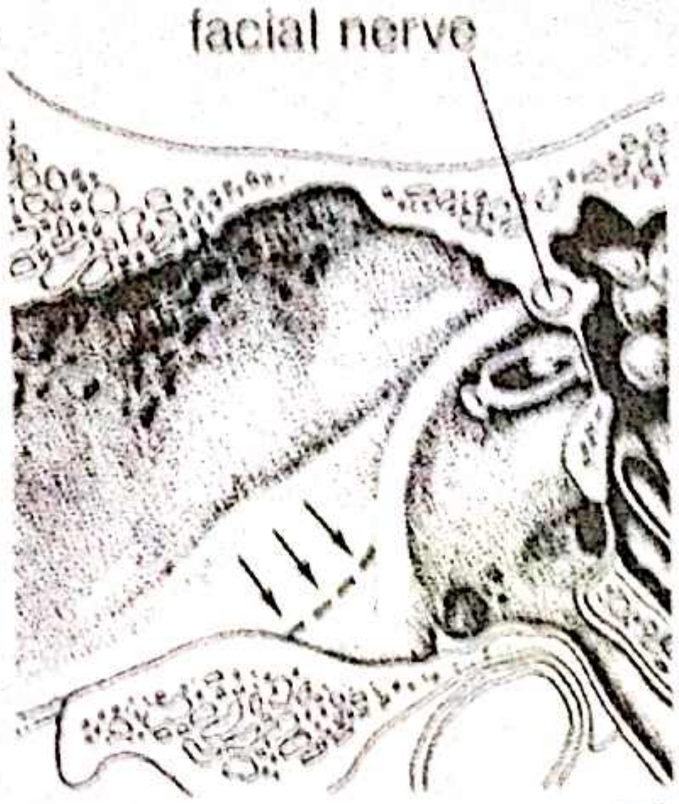
window no further exposure is required. Usually the cholesteatoma bulges down on to the stapedial crura and is separated from the rest of the tympanum by a mucosal fold attached to the head of the stapes and can therefore be readily dissected without damaging the stapes. Occasionally the cholesteatoma bulges between the crura and if it cannot be easily lifted out the crura can be cut with a rotating saw to allow access. The chorda tympani is easily displaced and preserved if free of matrix.

Destruction of the stapes superstructure by cholesteatoma and granulation tissue indicates more extensive disease, with infiltration of the tympanum and sinus tympani, which requires the additional exposure of a tympanomastoidectomy.

Lowering of facial ridge

30

After complete excision of the cholesteatoma the facial ridge must be lowered to provide a correctly shaped cavity with ready access from the meatus. In this final step the remains of the posterior meatal wall are lowered to the level of the floor of the meatus in a horizontal plane and almost to the level of the facial canal or annulus in the vertical plane. The cruder bone work can be carried out with a cutting burr but the final part should be done with a diamond paste burr, working outwards, away from the facial canal itself. The surgeon should only be satisfied with a smooth entrance to the cavity flush with the meatus. In a sclerotic mastoid there is a smooth slope up to the sinodural angle and in a relatively cellular mastoid a gentle slope downwards towards the tip.

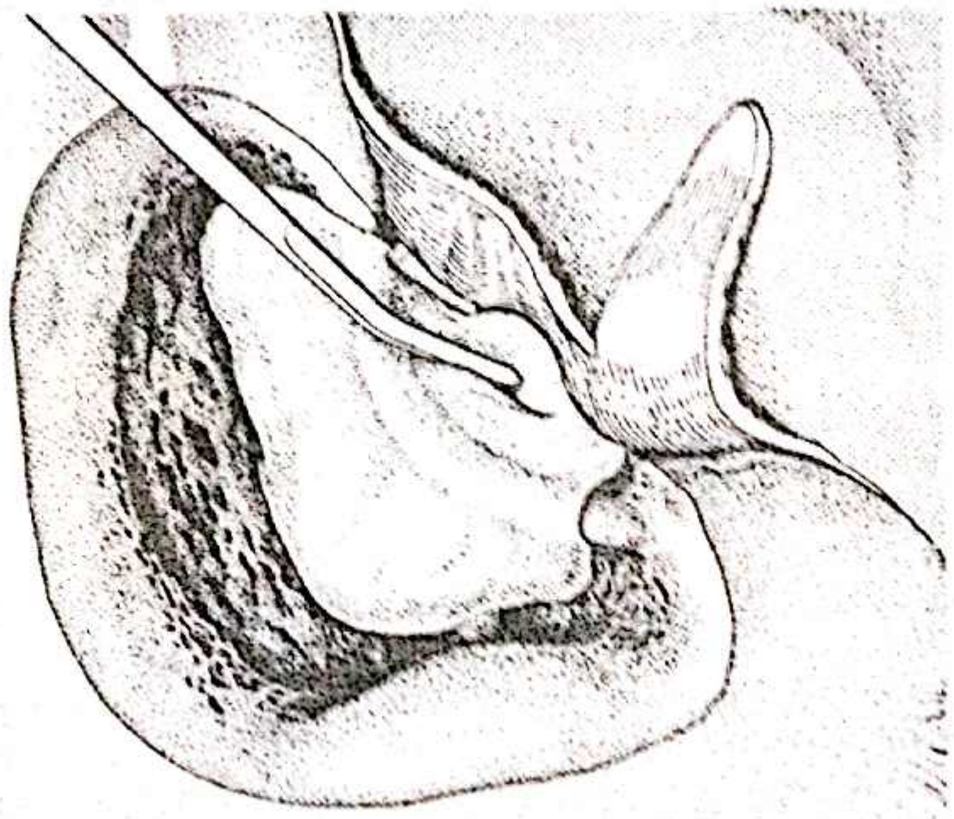


30

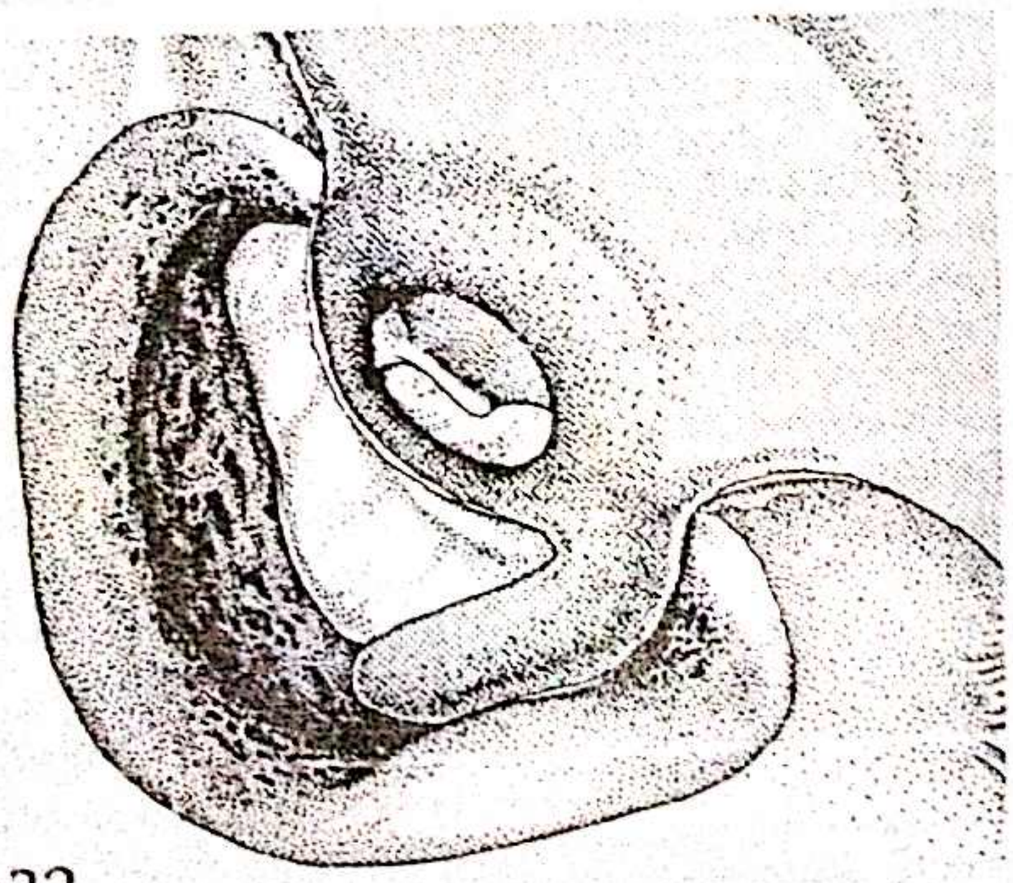
Placing the fascial graft

31

The previously prepared fascial graft is now trimmed and placed beneath the edge of the drum and reflected meatal skin flap to lie in contact with the head of the stapes, the facial canal and the medial wall of the epitympanum. It is usually unnecessary to place silastic within the tympanum if the tympanic mucosa is intact, but clotted blood or Sterispon may occasionally be needed to prevent collapse of the graft edge on to the medial wall of the tympanum. A homograft incus may be used for ossicular reconstruction before placing the fascial graft.



31



32

Replacing the skin flaps

32

The graft and meatal skin flaps are placed on top of the graft and held gently in position by Sterispon. The endaural or postaural wound is then closed and a 7.5 cm × 1.25 cm (3 in × 0.5 in) gauze pack soaked in BIPP is laid in the outer part of the meatus to displace the conchal flap backwards on to the outer part of the bony cavity.

The sutures and BIPP pack are removed on the fifth postoperative day and the cavity is left exposed to the air. A cotton wool pad may be loosely placed on the pinna for a further week or two to prevent soiling of the pillow at night. No further inspection is required for 2–3 weeks and then at less frequent intervals.

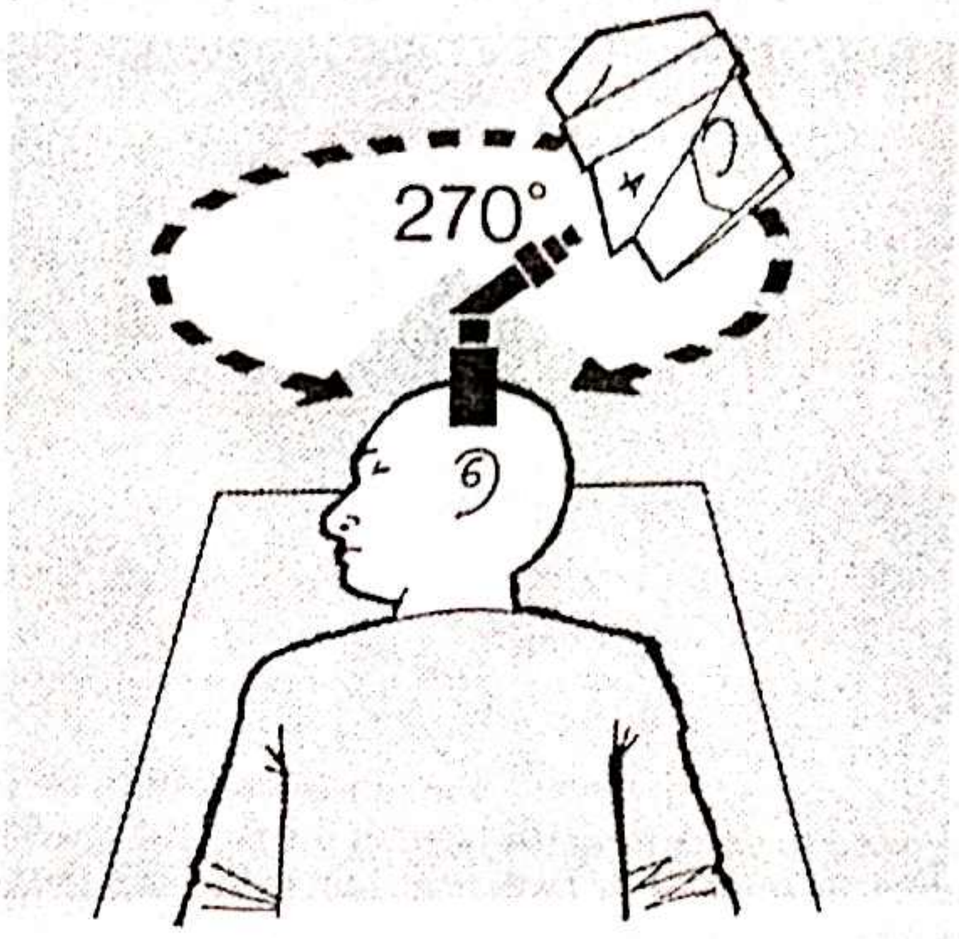
Tympanomastoidectomy

This additional exposure when the cholesteatomatous or granulomatous disease extends into the sinus tympani, the hypotympanum, and into and around the tympanic orifice of the Eustachian tube.

Position of surgeon

33

The preliminary stages of the operation are those of the epitympanomastoidectomy. To view the whole of the tympanum satisfactorily the surgeon's position can be altered through 270° and the patient's head through approximately 90°. This wide degree of positioning is required when working with oblique eyepieces on the microscope; with straight eyepieces the plane of rotation of the objective allows more comfortable viewing of the anterior, posterior and hypotympanum.



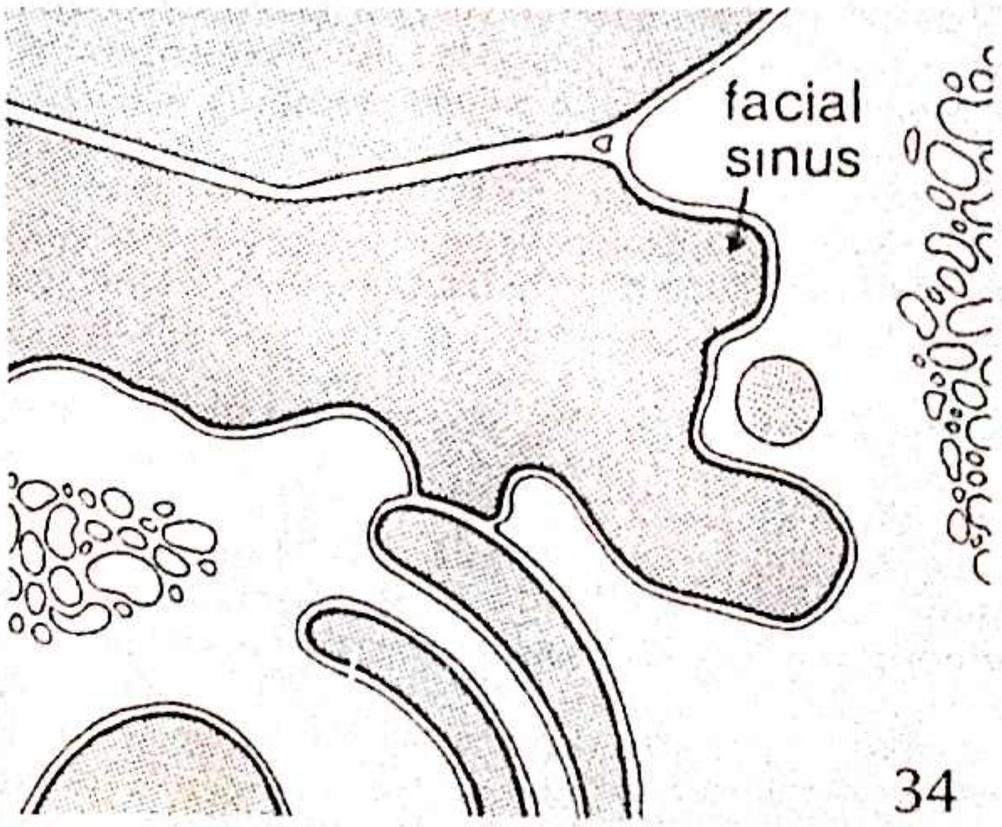
33

Exposure of sinus tympani

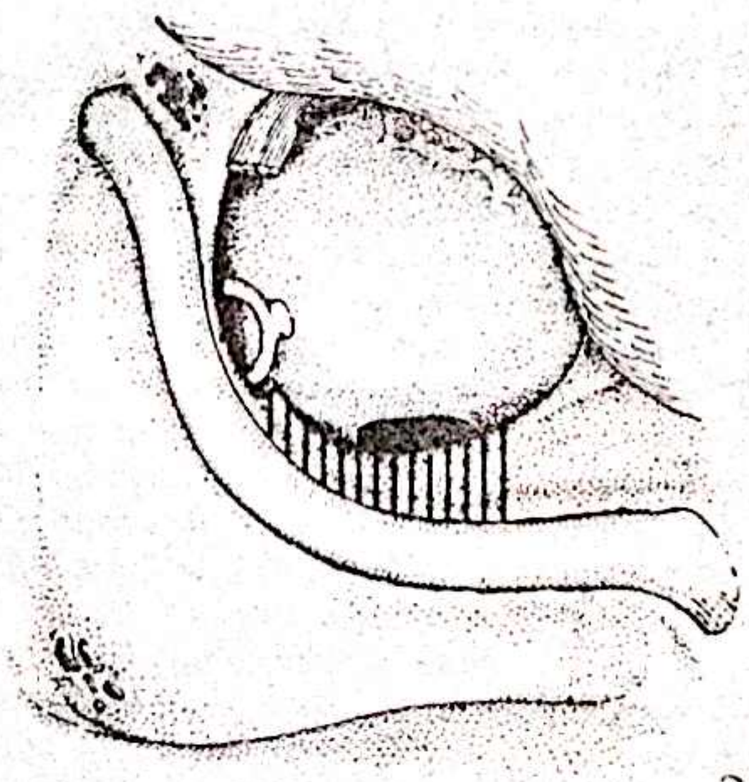
34 & 35

To gain adequate access to the sinus tympani, the annulus and tympanic remnant must be elevated and the facial ridge lowered to the level of the facial canal, so opening the facial sinus completely.

The deeper part of the sinus tympani can only be satisfactorily reached if the pyramid and the bone anterior to the facial nerve are also removed using fine diamond paste burrs. A shallow sinus tympani which accompanies a sclerotic petromastoid is then readily accessible. With rotation of the patient's head, adjustment of the straight-eyepiece microscope and repositioning of the surgeon, all but the very deep sinuses become accessible.



34

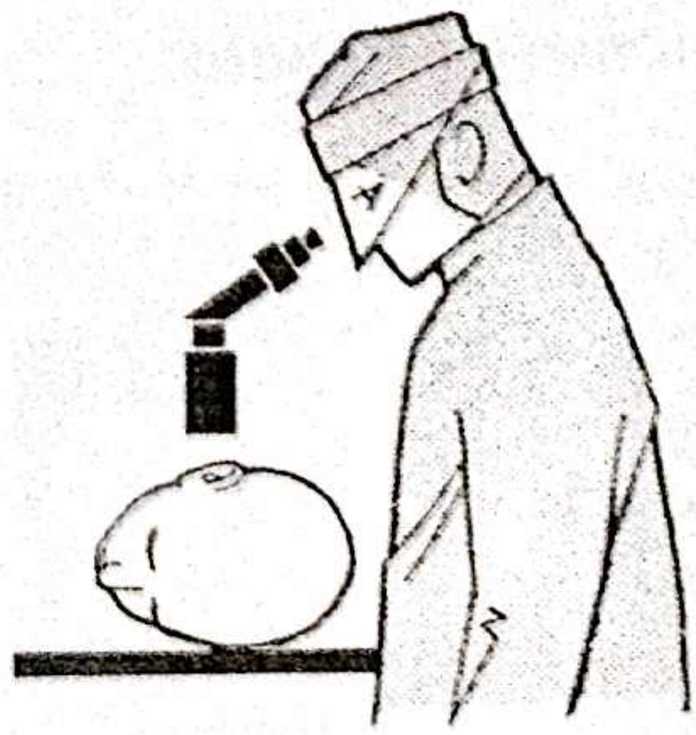


35

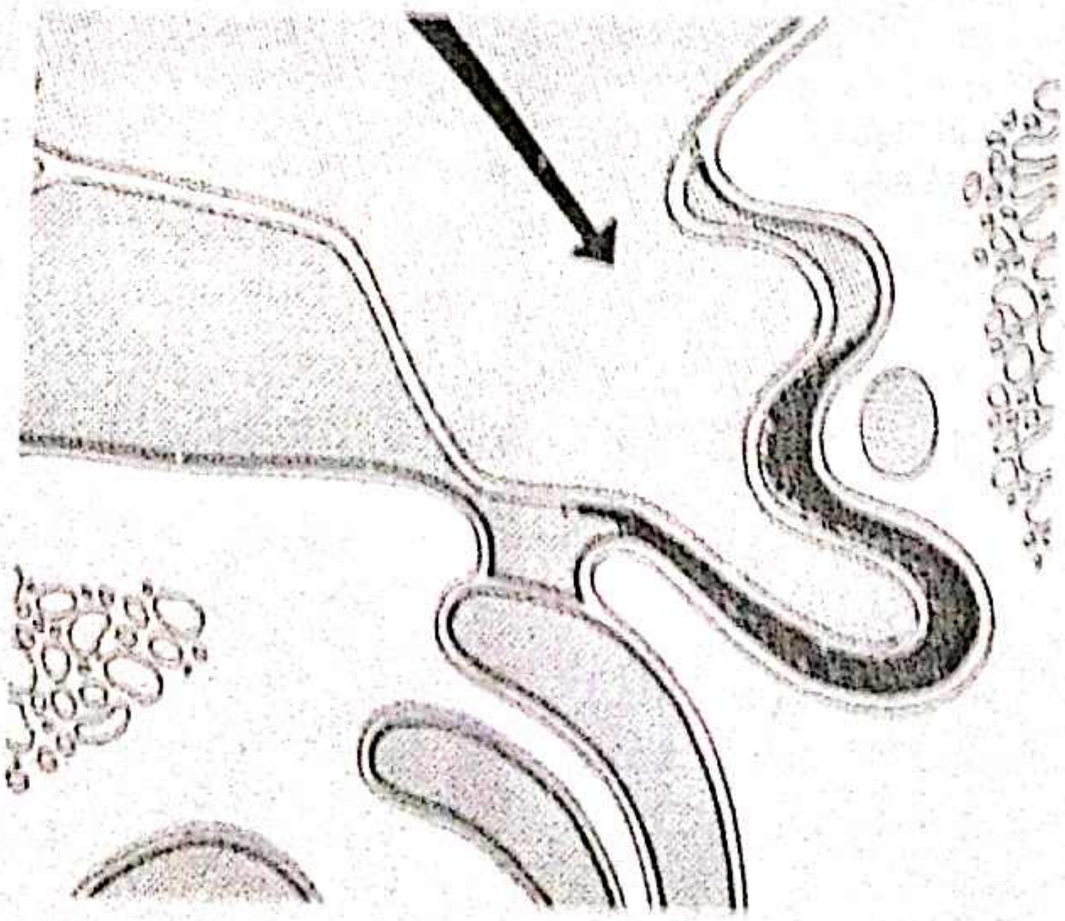
Viewing the sinus tympani

36

Using a microscope with inclined eyepieces the surgeon may need to work from the front of the patient and tilt the head at an angle of 25° away from him to see into the sinus tympani.



36



37

Anterior view of sinus tympani

37

An anterior view of the posterior tympanum can only be obtained with extensive lowering of the facial ridge.

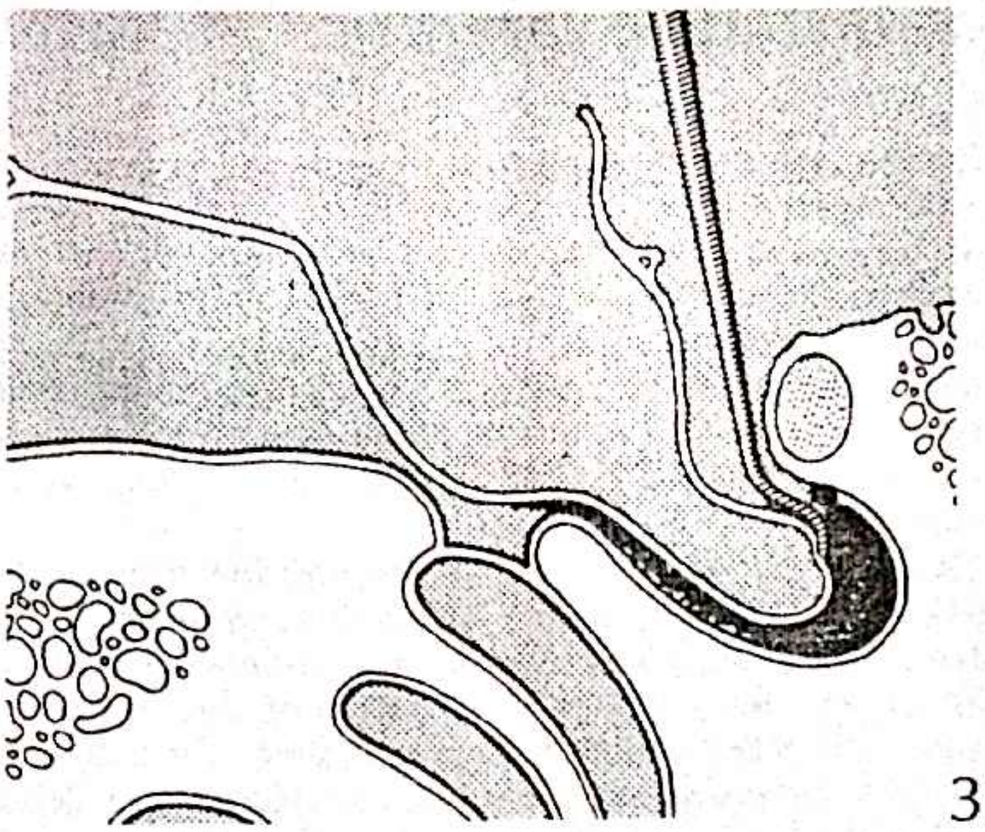
Removal of cholesteatoma from sinus tympani

38

With an adequately lowered facial ridge the cholesteatoma matrix can be elevated from the sinus tympani, working from above downwards. Only if it comes away in one clean swoop together with its covering mucosa can one be absolutely sure that it is entirely removed. The better the view the more certain the complete removal of remaining fragments of stratified squamous epithelium.

Granulations within the sinus tympani must be removed gently with fine excavators and without tugging by forceps in case they are attached to a naked facial nerve.

Cholesteatoma matrix can be peeled off a stapes footplate with care whereas granulations around the crura and footplate may be very difficult to remove since any inadvertent pulling may displace the stapes remnants. If a partial or complete stapedectomy results from clumsy manipulation it is absolutely essential to seal the window immediately with fascia to prevent a 'dead' ear. Granulation tissue should be dissected free of the underlying bone with fine needles and excavators before using forceps.



38

Tympanic dissection

39

After clearance of the sinus tympani the dissection is continued forwards across the mesotympanum, lifting the cholesteatoma matrix in continuity with the main mass. Provided the surgeon remains in the correct plane of dissection, the matrix can also be lifted from the hypotympanum and anterior tympanum in continuity. Thick granular mucous membrane on the promontory should also be removed and particular care must be taken while clearing the round window niche of granulations. Throughout, the dissection must be meticulous.

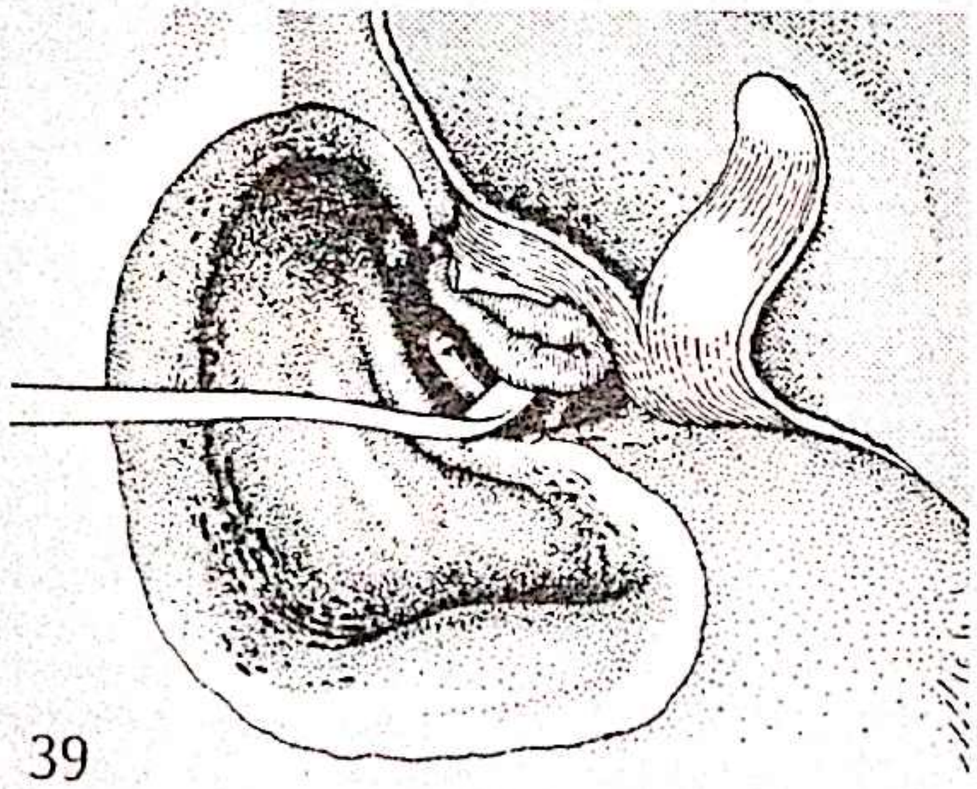
Cholesteatoma bulging into the orifice of the Eustachian tube can often be lifted out in one piece but occasionally it extends deep down into the tube, lining its walls, and cannot be excised. The deep surface of the tympanic membrane remnants is often lined by the cholesteatoma matrix and has to be removed together with the annulus and malleus handle.

After completing the dissection it is essential to seal the tympanum in order to prevent re-infection of the whole surgical cavity from the nasopharynx. A fascial graft is laid beneath any tympanic remnants or, if there are none, beneath the deep meatal skin of the anterior meatal wall which has been elevated to accommodate it. The graft should cover the whole tympanum and lie beneath any deep meatal skin flap. In the presence of an exposed facial nerve the fascial graft should not fully cover it, nor should excessive pressure be exerted upon it by firm packing.

With such extensive disease no attempt at ossicular reconstruction is made at this stage. However, if an almost intact stapes has been preserved, the medial wall of the tympanum may be covered with Silastic and the fascial graft placed against the head or crura of the stapes. The fascia is held gently in position with Sterispon, the wound is closed and a 7.5 × 1.25 cm (3 in × 0.5 in) BIPP pack is placed just within the meatus to hold the conchal flap in position and keep the wound closed.

The sutures and BIPP pack are removed after 5 days.

If the cavity heals satisfactorily, the meatus and tympanum can be reconstructed at a later stage.



39

Postoperative care

After the sutures and BIPP pack have been removed, the patient need not be seen for about 2–3 weeks, at which visit any supporting blood clot is removed and an antibiotic powder is insufflated. If there is no discharge the cavity is left untouched for a further 3 weeks, when the dried Sterispon is removed as a crust. The patient is then seen at less frequent intervals, depending on the state of the cavity, until it is healed, and thereafter annually or biannually.

Occasionally granulations develop in the roof of the meatus at the edges of the incision or along the facial ridge. These should be removed under microscopic control in the outpatient department or under an anaesthetic if the patient is uncooperative or a child. The presence of exuberant granulations usually only delays healing.

Failure of healing in the cavity is usually an indication of either inadequate surgery or extensive disease. Reoperation should only be considered if there is a reasonable chance of complete excision. In extensive disease a persistent discharge may be acceptable if the disease is under control and the ear can be regarded as safe.

Complications

Perichondritis

This is a very uncommon complication which usually follows faulty technique. The patient complains of wound discomfort within the first few postoperative days. If swelling persists despite antibiotic therapy and removal of the pack, the wound should be reopened and the dead cartilage removed before the infection spreads to involve the whole pinna.

Facial paralysis

If the operation has been performed correctly, the integrity or otherwise of the facial nerve should be known, and the light packing should not produce any further damage. Careful inspection during the operation should relieve the surgeon of this anxiety. However, if there is unexpected facial weakness immediately after the operation the cavity must be re-explored immediately. Facial paralysis may develop 1 or 2 days after the operation, particularly when the canal was found dehiscent; in this case the pack only needs to be removed to relieve pressure on the nerve.

Vertigo

Vertigo may result from drilling close to the lateral semicircular canal without adequate cooling. More often an erosion into the labyrinth or vestibule is the cause, and this should have been thoroughly investigated and dealt with at the time of the initial surgery. All patients with a fistula should be given antibiotic therapy and the vertigo should be controlled by chlorpromazine or barbiturates postoperatively. Unless a suppurative labyrinthitis has been induced by surgery the severe vertigo soon settles.

Perceptive deafness

A total loss of hearing may be the result of either the disease or clumsy surgery. No specific treatment other than that taken at surgery is required. A high-tone loss is sometimes the result of manipulations in the region of the round and oval windows and has to be accepted as a consequence of excising the disease.

Conductive deafness

Unless an intact and functional ossicular chain was preserved all patients must have a conductive deafness. Even attempts at ossicular reconstruction in the presence of such extensive disease may give disappointing results.

Intracranial pyogenic complications

These are practically unknown after competent surgery. Usually a preoperative complication has been overlooked and surgical intervention merely stirred the disease to become more evident. Adequate antibiotic cover in patients with invaded labyrinths prevents extension of the disease to the intracranial tissue planes.

Damage to the lateral sinus produces bleeding which is readily controlled by a small compressed temporalis muscle graft (the size of a postage stamp) which is tucked under the bony edges and held in position with a BIPP pack. Antibiotics should be given to prevent an inadvertent infection arising. Similarly, exposure of the middle fossa dura does not give rise to trouble if the disease is excised.

Illustrations by Gillian Lee

Combined approach tympanoplasty

C. W. Jansen MD
Chief, Ear, Nose and Throat Department, Municipal Hospital, Gummersbach, West Germany

The main objective of combined approach tympanoplasty is to remove all pathology in such a way that the anatomy of the external meatus, including the tympanic sulcus, remains intact. When the posterior bony canal wall has been partly or totally destroyed by a chronic process, the defects are reconstructed using autologous cartilage. An open mastoid cavity is avoided, in order to establish a closed aeration system. Aeration is improved by removing the blockage between the tympanum, the antrum and the mastoid cell system. In combination with a transmastoid access, the transcanal route is also used. The posterior tympanotomy technique was introduced by the author at the end of the 1950s as a result of intensive temporal bone work. It was found that only extensive thinning of the posterior bony canal wall in its mastoid portion enabled the surgeon to visualize all the spaces of the middle ear. The operating microscope in conjunction with the drill provided the technical basis for this new approach.

Restoration of the aeration system plays an important role in the reconstructive surgery of chronic middle ear disease. For that purpose the simple removal of polyps, granulations and cholesteatoma is not sufficient. Even the enlargement of the mastoid cavity with its spaces in the epi-, meso-, and hypotympanum provides immediate improvement in closed aeration after surgery. Complete breakdown of the aeration system occurs when the mastoid has been opened. The normally aerated cells are filled with granulations which invade the antrum and all spaces of the middle ear. In addition, after removal of the granulations there is still not enough room for sufficient ventilation. Consequently further enlargement of the bony cavity by drilling is needed. The formation of a big closed cavity is only effective when the epitympanum and the tympanic orifice of the Eustachian tube are enlarged. The procedure is performed using the transmastoid approach and without removal of the bony annulus. The ligaments remain intact.

In order to improve tympanic ventilation, removal of bone is needed to obtain an open space between the ossicular chain and the bony annulus in its mesotympanic region. This space is also very important for achieving wide access to the posterior part of the tympanum. Inferior to the fossa incudis, the hypotympanotomy is performed by drilling away the bone between the chorda tympani and the facial canal. The facial nerve is not decompressed routinely. The transcanal view has an important part to play in combined approach tympanoplasty after detachment of the meatal skin lining in its superior, medial and inferior portion. Transcanal inspection is a great additional advantage and gives the surgeon another angle of view from which to work.

Positioning of the graft is done by the transcanal route.

Illustrations by Gillian Lee

Combined approach tympanoplasty

C. W. Jansen MD
Chief, Ear, Nose and Throat Department, Municipal Hospital, Gummersbach, West Germany

The main objective of combined approach tympanoplasty is to remove all pathology in such a way that the anatomy of the external meatus, including the tympanic sulcus, remains intact. When the posterior bony canal wall has been partly or totally destroyed by a chronic process, the defects are reconstructed using autologous cartilage. An open mastoid cavity is avoided, in order to establish a closed aeration system. Aeration is improved by removing the blockage between the tympanum, the antrum and the mastoid cell system. In combination with a transmastoid access, the transcanal route is also used. The posterior tympanotomy technique was introduced by the author at the end of the 1950s as a result of intensive temporal bone work. It was found that only extensive thinning of the posterior bony canal wall in its mastoid portion enabled the surgeon to visualize all the spaces of the middle ear. The operating microscope in conjunction with the drill provided the technical basis for this new approach.

Restoration of the aeration system plays an important role in the reconstructive surgery of chronic middle ear disease. For that purpose the simple removal of polyps, granulations and chloesteatoma is not sufficient. Even the enlargement of the mastoid cavity with its spaces in the epi-, meso-, and hypotympanum provides immediate improvement in closed aeration after surgery. Complete breakdown of the aeration system occurs when the mastoid has been opened. The normally aerated cells are filled with granulations which invade the antrum and all spaces of the middle ear. In addition, after removal of the granulations there is still not enough room for sufficient ventilation. Consequently further enlargement of the bony cavity by drilling is needed. The formation of a big closed cavity is only effective when the epitympanum and the tympanic orifice of the Eustachian tube are enlarged. The procedure is performed using the transmastoid approach and without removal of the bony annulus. The ligaments remain intact.

In order to improve tympanic ventilation, removal of bone is needed to obtain an open space between the ossicular chain and the bony annulus in its mesotympanic region. This space is also very important for achieving wide access to the posterior part of the tympanum. Inferior to the fossa incudis, the hypotympanotomy is performed by drilling away the bone between the chorda tympani and the facial canal. The facial nerve is not decompressed routinely. The transcanal view has an important part to play in combined approach tympanoplasty after detachment of the meatal skin lining in its superior, medial and inferior portion. Transcanal inspection is a great additional advantage and gives the surgeon another angle of view from which to work.

Positioning of the graft is done by the transcanal route.

Indications for combined approach tympanoplasty

The combined approach procedure is suitable for the surgical treatment of acute and chronic middle ear disease, including cholesteatoma. Transmastoid posterior tympanotomy can also be done as a single procedure. One of the frequent indications, for example, is seromucinous otitis media, or 'glue ear'. When treatment by the insertion of grommets has failed, posterior tympanotomy with wide opening of the Eustachian tube entrance has solved the problem in most cases.

Contraindications

A simple mastoidectomy, with or without opening of the facial recess, is not comparable to a posterior tympanotomy. Nor are acceptable results achieved with modifications to the procedure. Only experienced surgeons should take responsibility for performing posterior tympanotomy. A high incidence of recurrent cholesteatoma demonstrates the limitation in the surgeon.

In most cases of malignant tumours preservation of the meatus is contraindicated. Fistulae of the semicircular canal system should be considered. In our experience, preservation of the meatus is a great advantage for the patient. Caloric and other irritations are aggravated when the posterior wall has been removed. Hearing is made worse as a consequence of having three windows. Even in these cases closed but wide space is of great advantage. There is no pressure of graft on top of the fistula, and in most cases second-stage intervention will show a small cholesteatoma pearl which can be removed easily.

Preoperative

Use of Siegle's speculum and of the microscope is part of preoperative assessment, together with the use of tuning forks and standard tests of tubal function. With experience the surgeon can obtain useful information with Eustachian tube tests. X-rays are done routinely. The Schueller and Stenvers projections are most often used. The course of the sigmoid sinus and the area of the mastoids including the extensions of the cell system and the dural border, are of importance for this procedure.

Bacteriological tests are done in most cases. Both wet and barely infected ears which have not become dry with intensive antibiotic treatment may need urgent surgical intervention. More than 75 per cent of our cases belong to this category. Unfortunately most statistics do not mention the rate of wet and infected ears. The purpose of the posterior tympanotomy is to achieve a dry ear, especially in problematic cases. Antibiotics are given pre- and postoperatively. Antiallergic drugs are rarely needed but are taken into account, as well as conditions such as diabetes and hypertension.

Anaesthesia

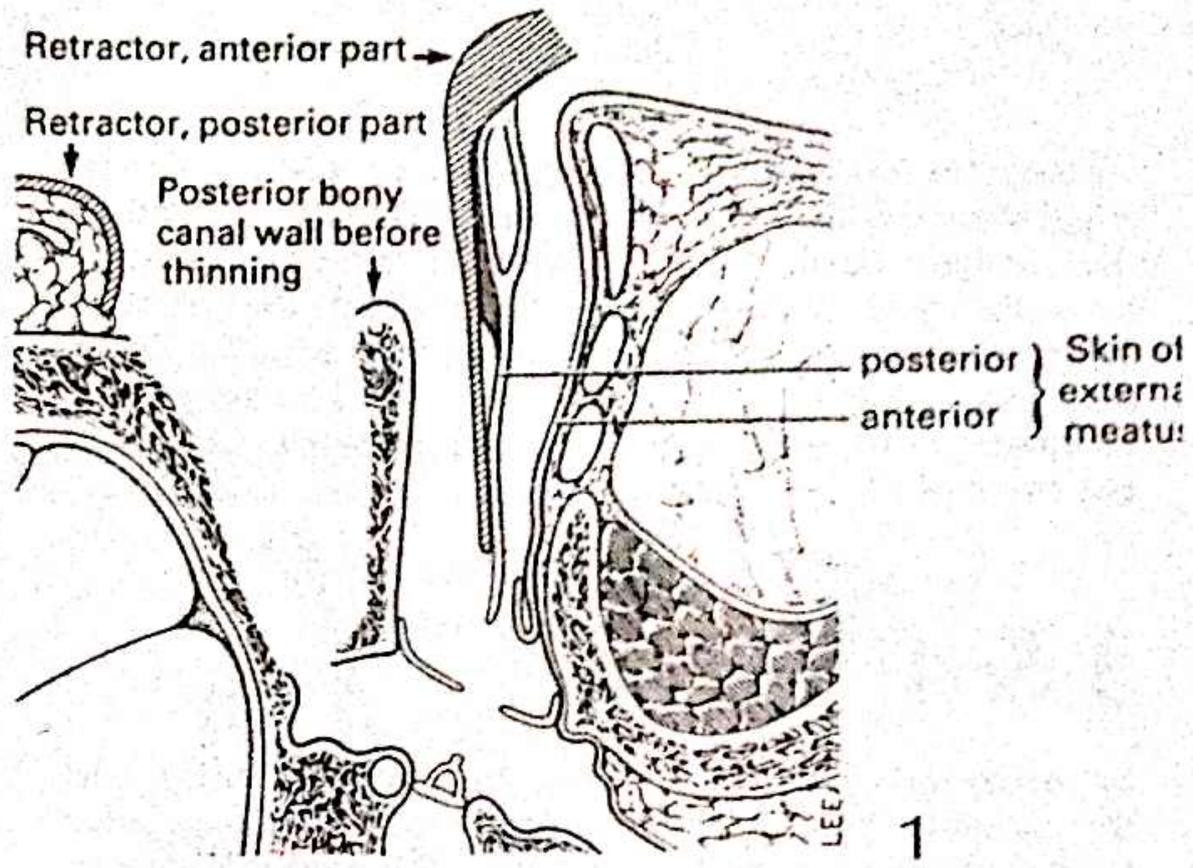
General anaesthesia is used for mastoid surgery in almost all cases. Only patients who cannot tolerate general anaesthesia are operated on under local anaesthesia. Hypotension is not often used. Uncontrolled bleeding occurs more often after hypotension, and may cause dislocation of the graft or interposed material.

Informing the patient

The patient should be informed clearly about the surgical procedure. It is a good idea to prepare a small booklet which explains the operation in words and pictures.

The operation

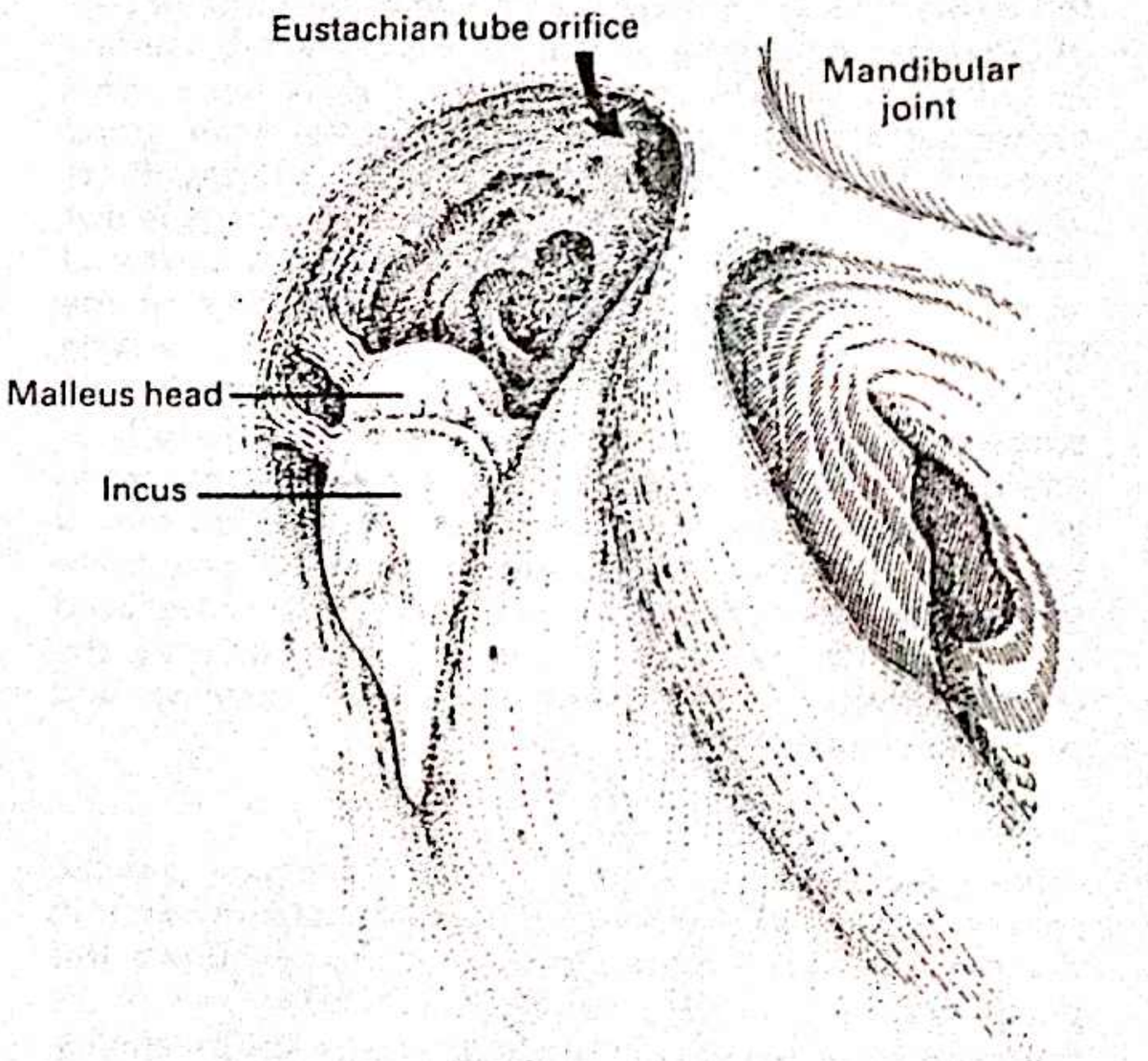
The incision is made in the postauricular fold and extends from the superior to the inferior end of the auricle. The incision undermines the conical-shaped portion of the auricle but it does not go through the subcutaneous tissue and periosteum. A pedicle graft of connective tissue and periosteum is formed by a second incision posteriorly when the posterior part of the skin is drawn backwards with a retractor. The pedicle graft is detached carefully from the bone until the spine of Henle is identified. The solid external portion of the meatal skin is carefully detached from the bony meatus in its posterior, superior and inferior parts. No incision is made in the external membranous meatus.



1

1 & 2

Without using the microscope, an antrostomy is performed. It is left to the discretion of the surgeon to decide at which stage of the mastoidectomy the microscope is to be used. *Illustration 1* shows a simple mastoidectomy in a right ear without the malleus and incus. *Illustration 2* shows the transmastoid view of the situation, which is later explained in detail.

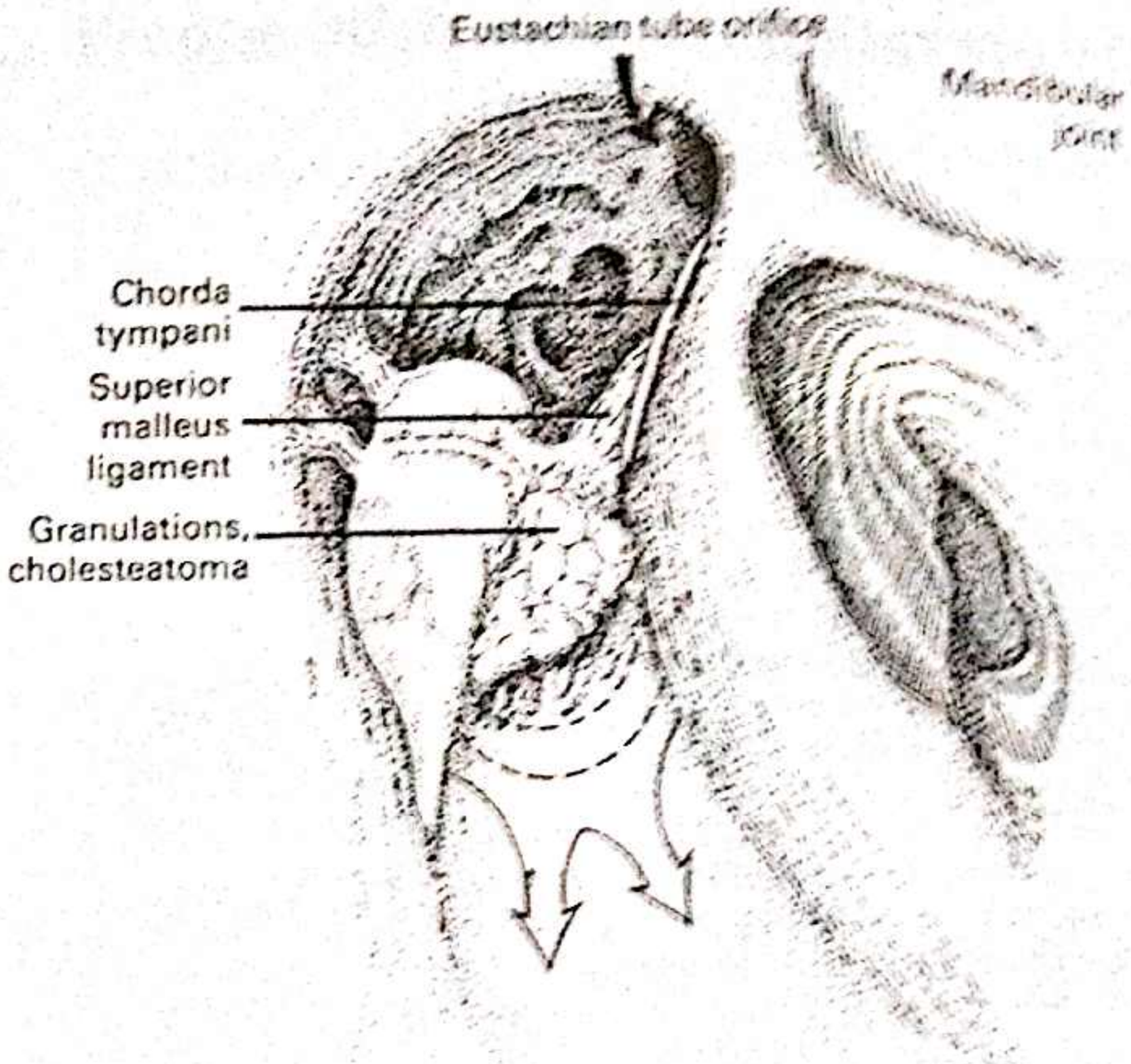


2

When a lot of powder is to be expected due to extensive bone work, a combined handpiece for irrigation and suction works very well. This also involves the use of a straight handpiece for drilling. When persistent irrigation is used the temperature of the rinsing solution is critical. In our experience rinsing with a solution below normal body temperature leads to significant inner ear damage with high tone loss. The tank with the rinsing solution should be maintained at about 5° C above body temperature. An automatic system is needed to ensure this. New technical equipment shows the temperature at the distal end of the irrigating system. When the finer work is started, suction and irrigation are separated, but the temperature controlling system must still work. Strong suction close to the oval and round window niche should be avoided because of the noise and the cooling effect.

In contrast to simple mastoidectomy, a wide opening of the epitympanum can be seen in *Illustration 2*. Extensive atticotomy and epitympanotomy play an important part in this procedure as they improve Eustachian tube function. One of the most common failures is leaving intact the solid portion of bone superior to the malleus head. This is called the superior barricade and it must be removed in order to provide additional aeration of the mastoid. In a dry and non-infected ear the mucosal lining is flat and allows normal aeration. In infected ears the mucosal lining swells conspicuously. In such circumstances no space is left and aeration stops completely. This procedure involves the wide enlargement of all paths for aeration between the tympanum and the mastoid. For that purpose, and in order to create a reserve of aeration, the mastoid also is opened widely to the antrum and enlarged. In heavily infected ears the superior opening is sufficient when the Eustachian tube orifice can be seen. In such cases a small plastic tube can be inserted, and remain in place for several days. The tube comes out of the incision and can be removed very simply.

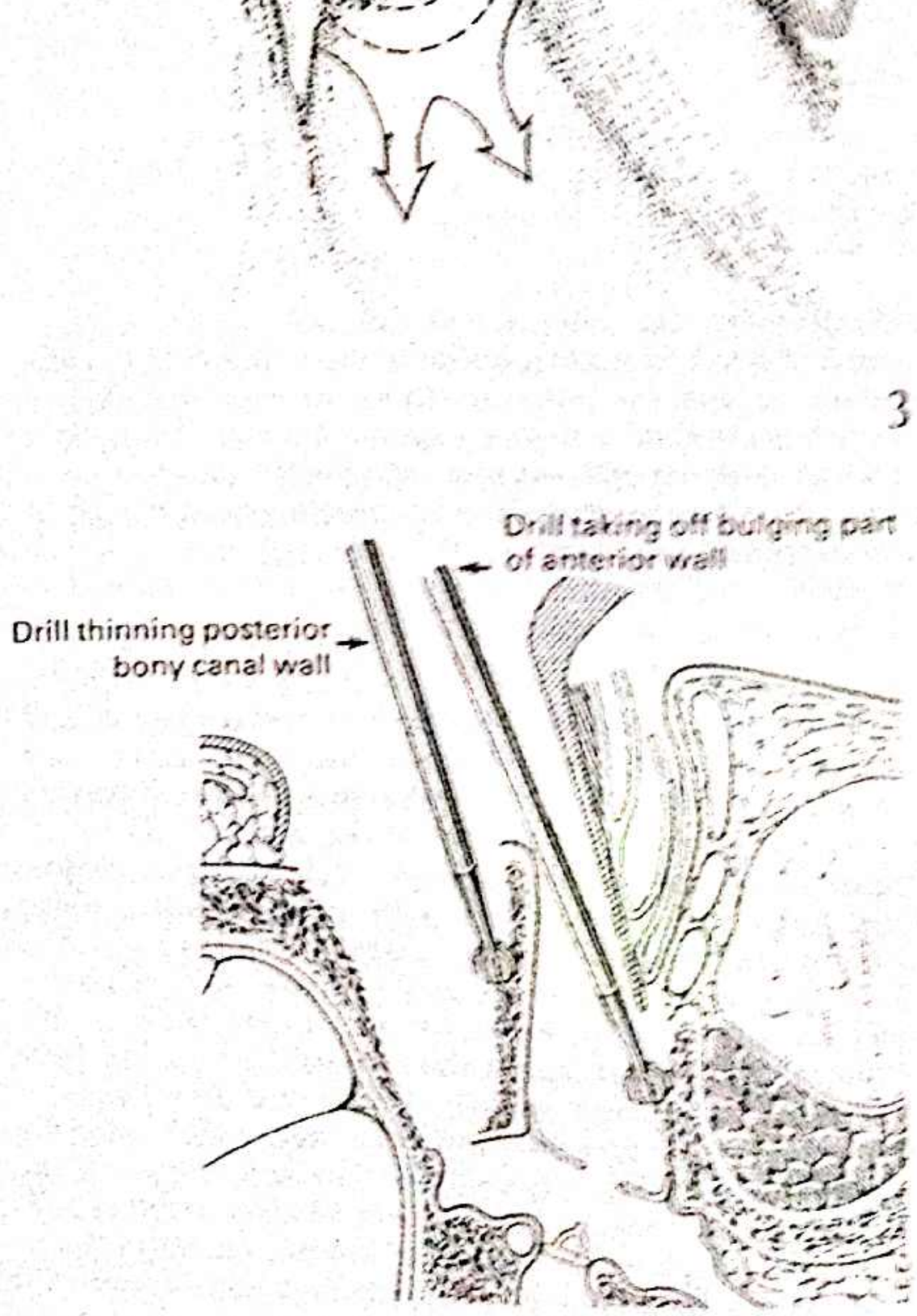
Using the microscope, an angled handpiece and a very small diamond drill, the bone close to the superior end of the malleus head is taken away. In order to prevent potential inner ear damage, the malleus and other parts of the ossicular chain should not be touched with the tip of the drill. A bigger drill is used carefully to enlarge the entrance to the epitympanum. The superior landmark is the dural plate.



3

3 & 4

Superoanteriorly and anteriorly the chorda tympani and the superior ligament of the malleus can be seen after further thinning of the bony meatus. The medial border of epi- and pre-tympanum is its *bottom* with the tendon of the tensor tympani muscle. By drilling of the anterior part of the pretympanum the lateral portion of the tubal orifice is enlarged and the tube can be clearly seen. This technique for opening the tube is better than going through the tympanic cavity because it provides direct access without any curve. An additional advantage is that the procedure is performed behind the bony canal wall and without damaging the superoanterior part of the tympanum. This technique of opening the Eustachian tube orifice is also used as the first part of Eustachian tube surgery. No further drilling should be done anteriorly or anteroinferiorly because there is a risk to the carotid artery. The mucosal lining in its posterior portion should be detached before drilling. After removal of some bone to enlarge the orifice, the mucosal lining is replaced backwards. In our experience the recreation of the mucosa starts at this point after wide opening and provides ventilation.



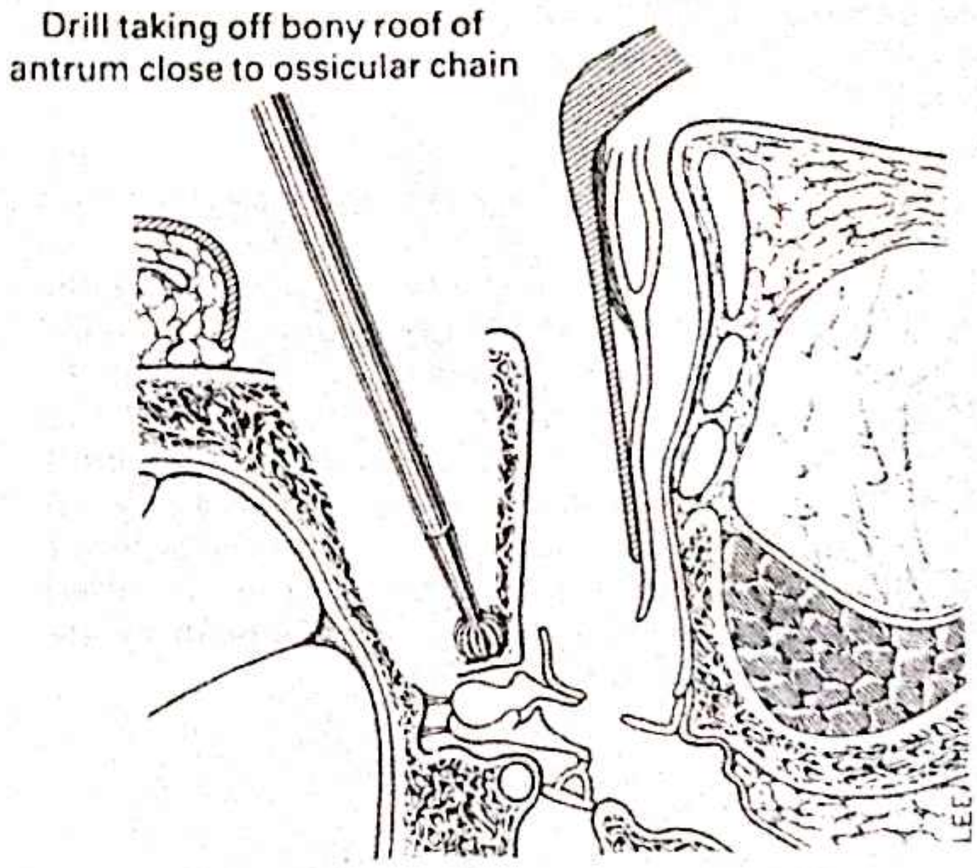
4

Next the bone between the chorda tympani and the short process of the incus is removed to open the door to the mesotympanic space. In order to flatten down this portion of bone further thinning of the inferior part of the posterior bony canal wall is needed. Under low magnification the thinning is done with inspection of both sides of the bony meatus to prevent perforations. A special retractor with a long blade (*see Illustration 1*) keeps the posterior portion of the meatal skin forward. This allows good inspection of the meatus and enables the surgeon to remove the bony crest of the tympanosquamosal line. In the case of a bulging anterior bony meatus, it can be removed simply after the skin is detached carefully (*see Illustrations 3 and 4*).

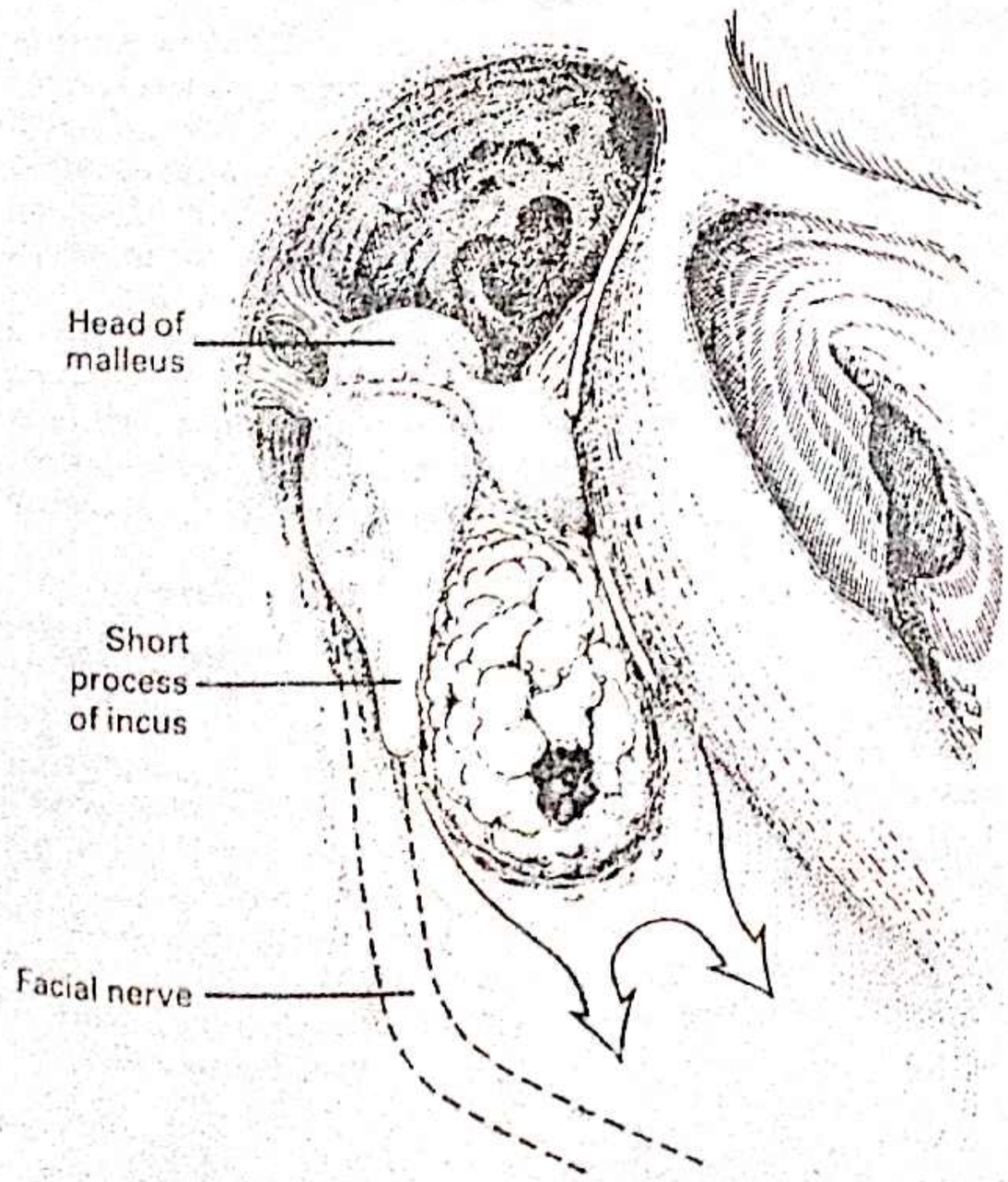
5–8

The bony portion is removed progressively but carefully, without touching the malleus or the incus. After partial removal of pathology, the depth of the hypotympanic space is tested using a series of hooks (see *Illustration 9*).

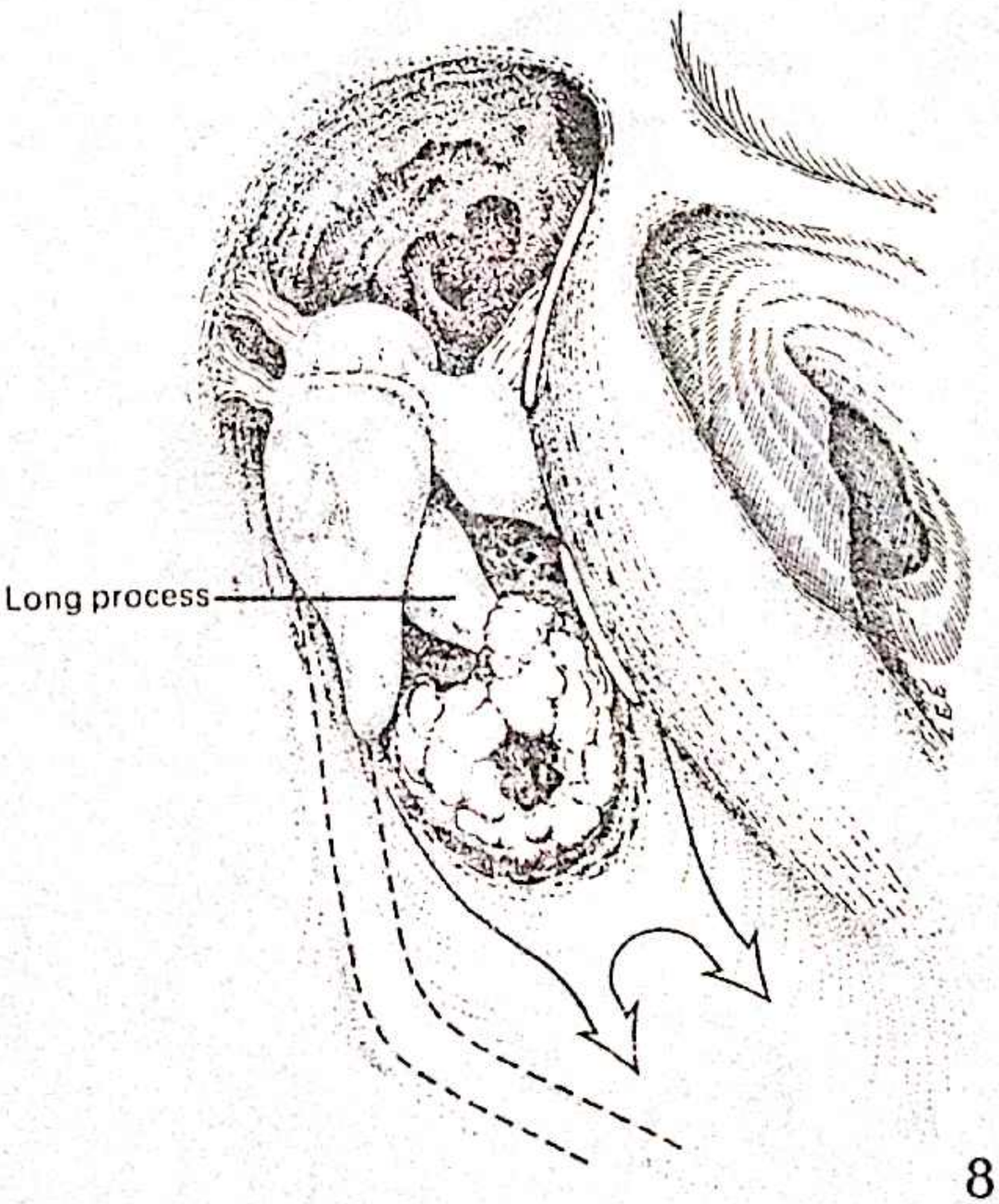
5



6



7

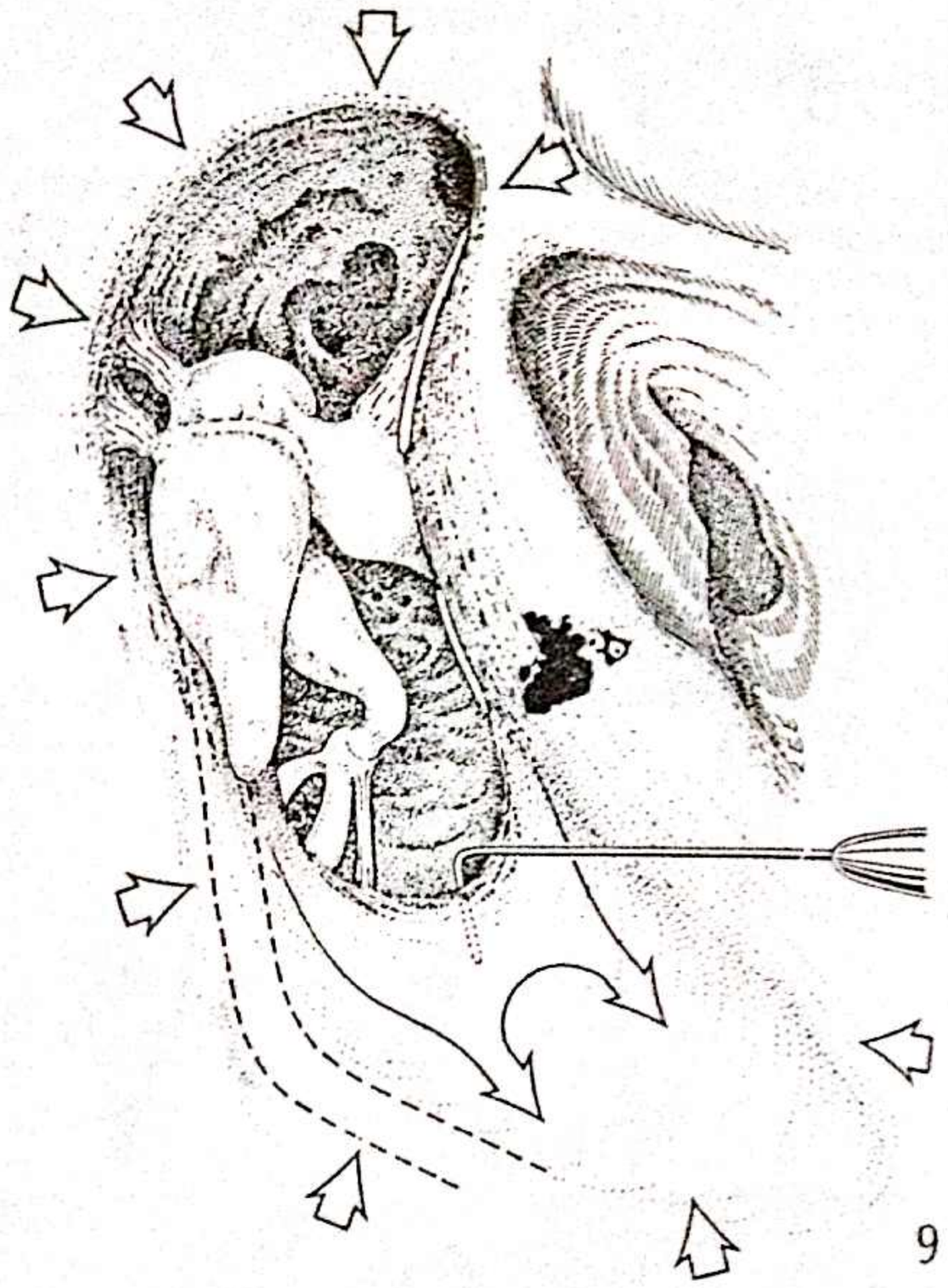


8

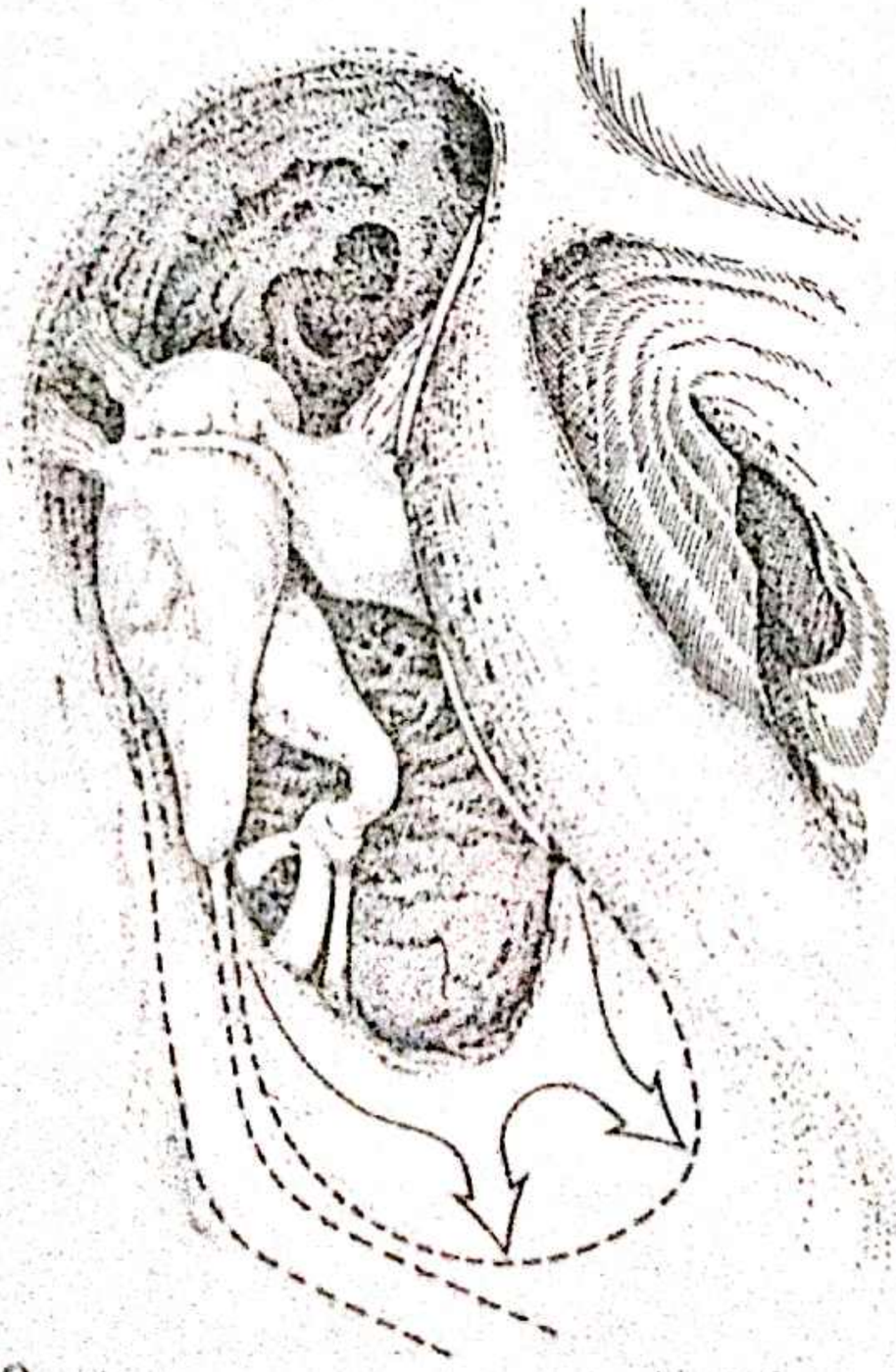
9, 10 & 11

Special attention should be paid at this stage to obtaining different angles of view with the microscope (*9 and 11*). The estimated border of the remaining portion of bone to be removed by drilling is indicated in *Illustration 9*. In order to avoid risk of inner ear damage or damage to the facial nerve a diamond drill is used. High-speed rotation is avoided because of the heat and noise. The prolonged axis of rotation and the horizontal line coming from the most inferior border of the annulus meet at an angle of 90 degrees. Here, at the meeting area of the two imaginary lines, the risk of opening the bony cover of the facial nerve is extremely high.

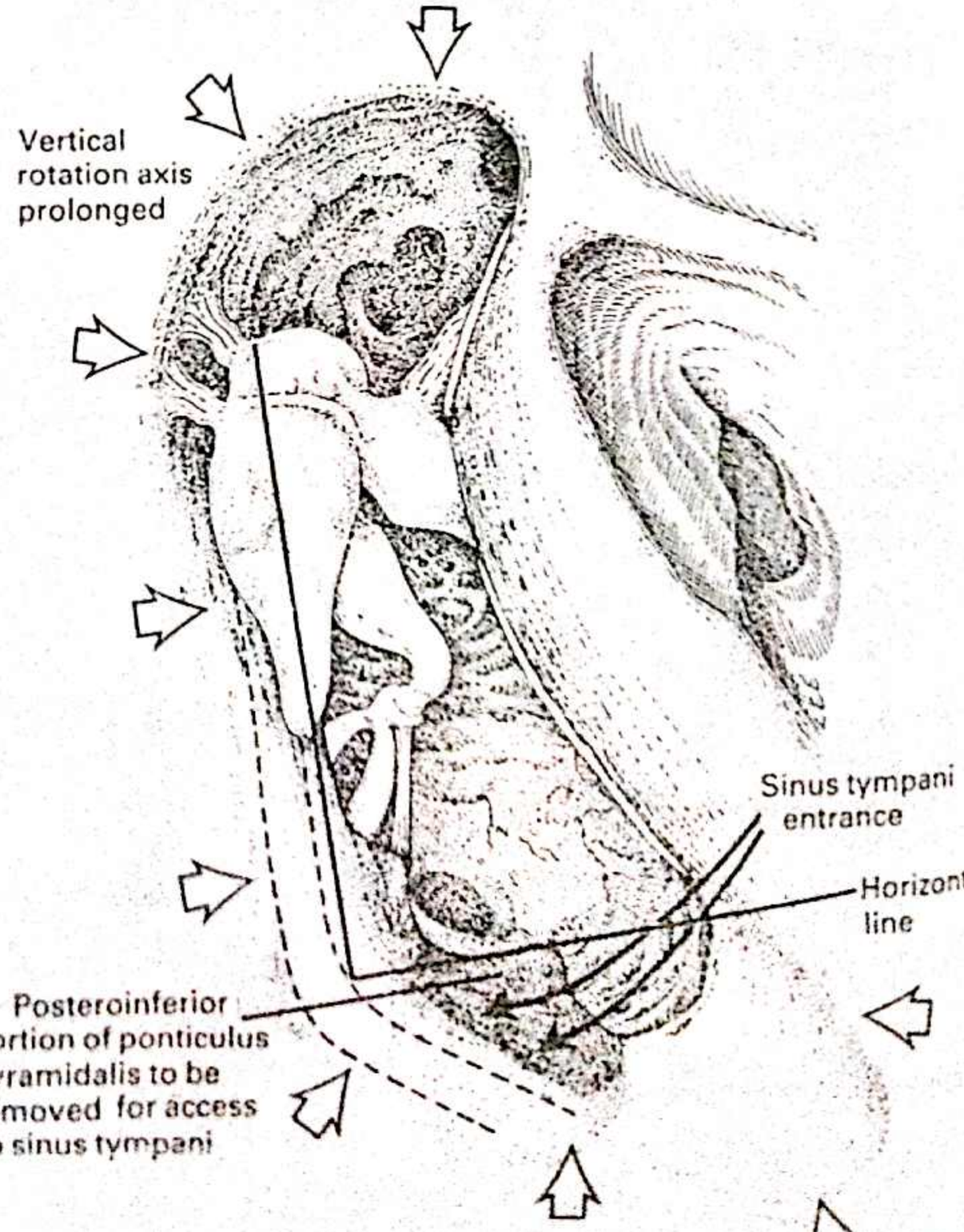
In order to achieve wide access to the sinus tympani, the posteroinferior portion of the ponticulus pyramidalis has to be removed as well. The arrows in *Illustration 11* indicate the different angles of view gained with the straight binocular system of the microscope. The bent system is not very useful in posterior tympanotomy. In order to render a very flat angle of view into the anterior part of the tympanum the operating table is lifted upwards. Additional turning of the patient's head to the opposite side facilitates the procedure.



9



10



11

12

In order to inspect the region underneath the ossicular chain, in the same flat angle of view, the short process of the incus may be lifted carefully.

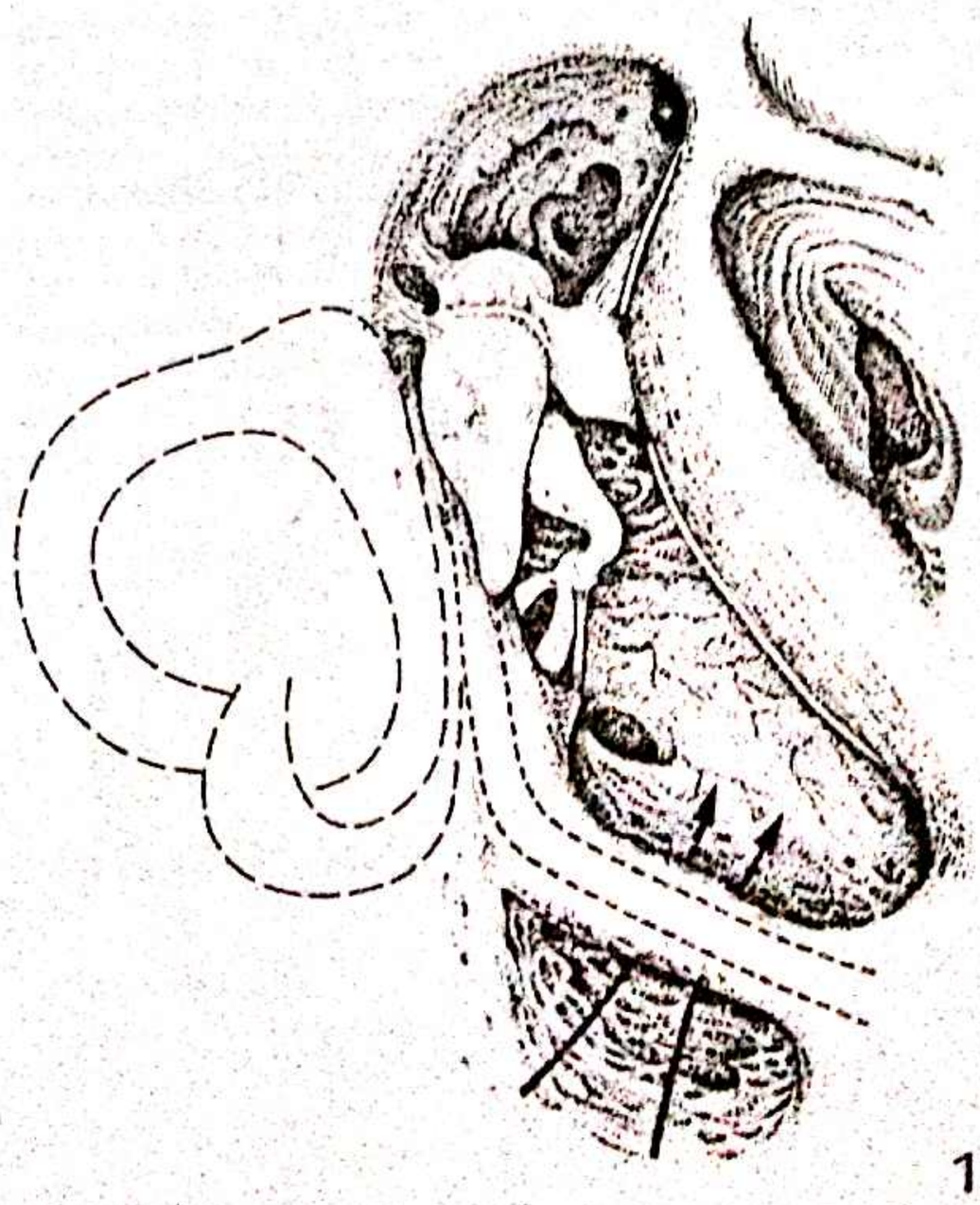
13

The technique of undermining the facial nerve may be required for other procedures. In cases with a deep posterior sinus tympani, complete removal of pathology can be achieved.

The facial canal is only opened when there is special demand. As far as the mucosal lining is concerned it is our practice not to remove mucosa unless it is essential because of cholesteatoma which has obviously grown in. Only polyps and granulations are removed. It is the re-aeration in a closed physiological system which renders possible a fast healing process under almost normal conditions.

Cholesteatoma

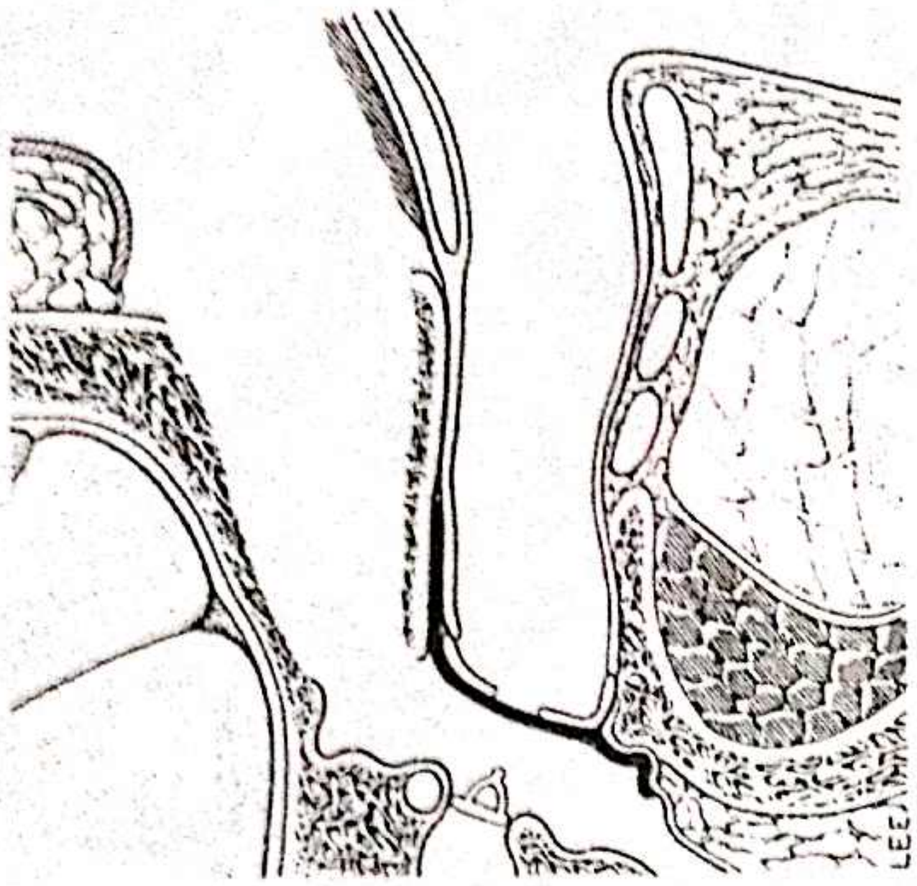
In cases with cholesteatoma the technique of posterior tympanotomy is carried out as described above. Where defects of the attic have been caused by cholesteatoma, posterior tympanotomy is our method of choice. There is no doubt that the transmastoid access provides the best exposure to all the spaces of the middle ear. The transcanal procedure has its advantages but, for adequate access to the middle ear, the surgeon has to sacrifice the posterior bony canal wall or at least large parts of it. In this way the retraction pocket is pre-programmed. The combined approach tympanoplasty combines the two techniques, thus avoiding their disadvantages.



All defects in the bony canal wall are repaired on the spot. Autologous cartilage is the material of choice for cartilaginous reconstruction of the posterior bony canal wall. Since this technique has been adopted by other authors the rate of recurrent cholesteatoma has been greatly reduced. Additional removal of bone from the borders of the meatal defects is needed to avoid another risk of cholesteatoma recurrence. Polishing with the diamond drill after detachment of the cholesteatoma matrix should also be mentioned here. In removing all potential cholesteatoma it works very effectively, especially in the mastoid bowl.

Tympanoplasty

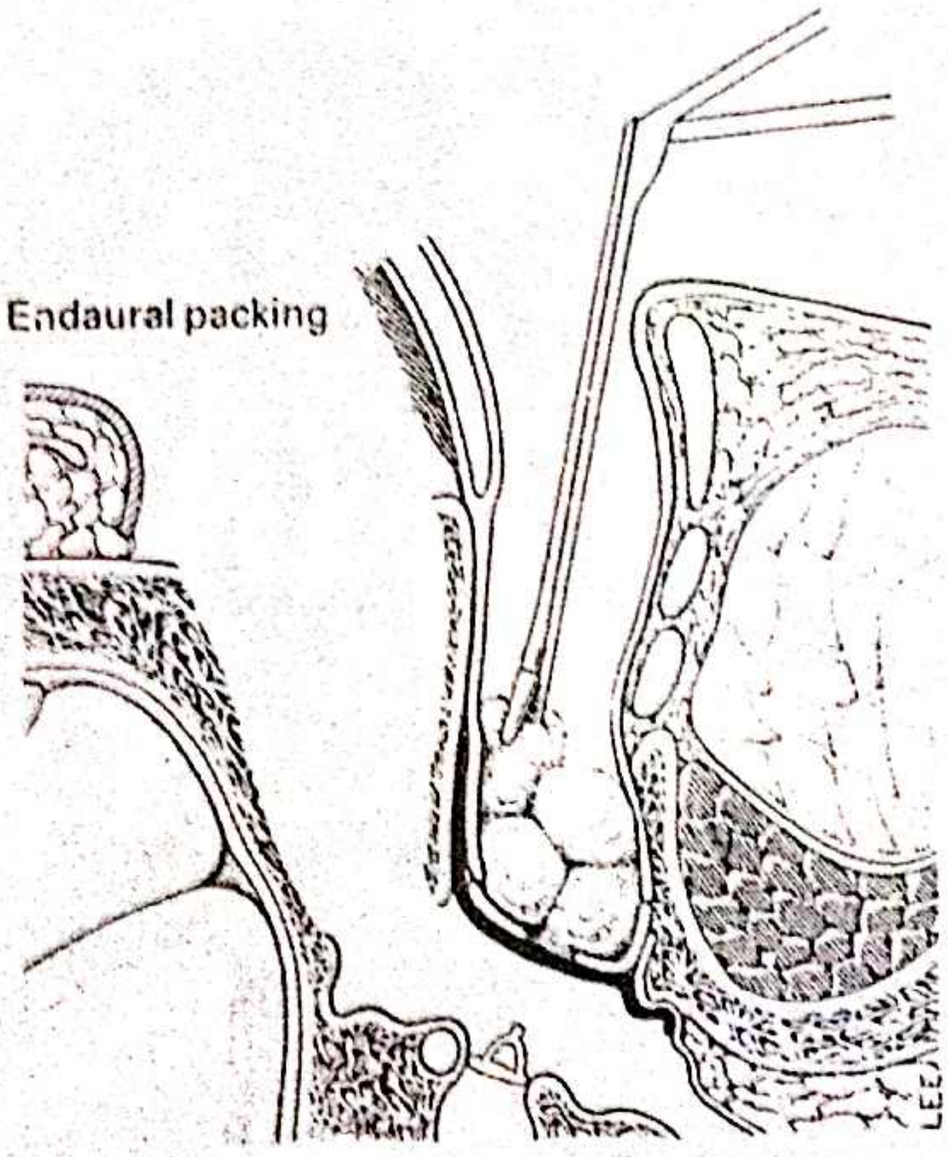
In order to repair the drumhead, a xenograft has been used successfully for about 15 years. It is called xeno-serosa and is made from calf's intestine. It contains elastic fibres as well as collagenous fibres. This membrane is much thinner than any other material but is very strong. Its greatest advantage is its non-hydroscopic behaviour. In contrast to nearly all other grafts it does not swell up after positioning. It serves simply as a scaffold which is overgrown by the mucosal lining on its tympanic aspect and by the squamous epithelial layer on its external aspect. Xeno-serosa is placed on top of a piece of rubber glove, which is carefully removed after the serosa is in place. Other grafts can be used in the same way.



14

The underlay technique is preferred. The graft is always placed on top of the posterior bony canal wall. On top of the graft the skin is replaced and glued with fibrin glue to the bone on one side and to the skin on the other side. The nutrition of the graft is optimal and is not comparable to any technique with an open cavity. Under these conditions quick healing is the norm.

Of course there are other possible methods of grafting. After complete de-epithelization of the drumhead remnant, the overlay technique can also be employed. In this case the skin lining has to be mobilized from the bony canal wall all round lateral to the annulus. About 5 mm are needed at the anterior part because the skin lining has to cover the graft.

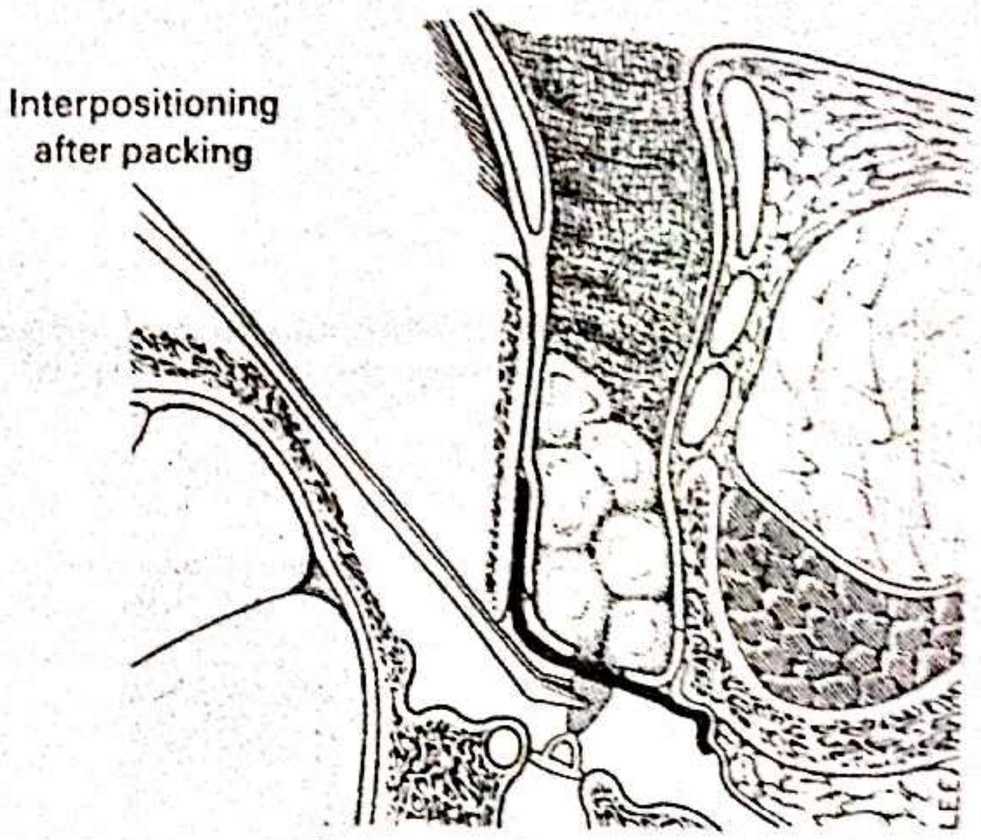


15

Gelfoam, including the gauze strip, is placed in position

16

Interpositioning can be done when grafting has been finished – one of the great advantages with posterior tympanotomy. Autologous cartilage is the preferred material for interpositioning. In most cases the tympanic cavity is left free of gelfoam. Sometimes gelfilm is used in pieces to support the graft from the tympanic side.



16

Modelled remnants of ossicles or ceramics are used for the reconstruction of the sound-conducting apparatus. The long T-prosthesis is taken for interpositioning in cases where only the footplate remains intact. This type of prosthesis can be shaped out of cartilage taken from the auricle or from the tragus. The best material for a long T-prosthesis is the strongest autologous cartilage from the rib or septal cartilage.

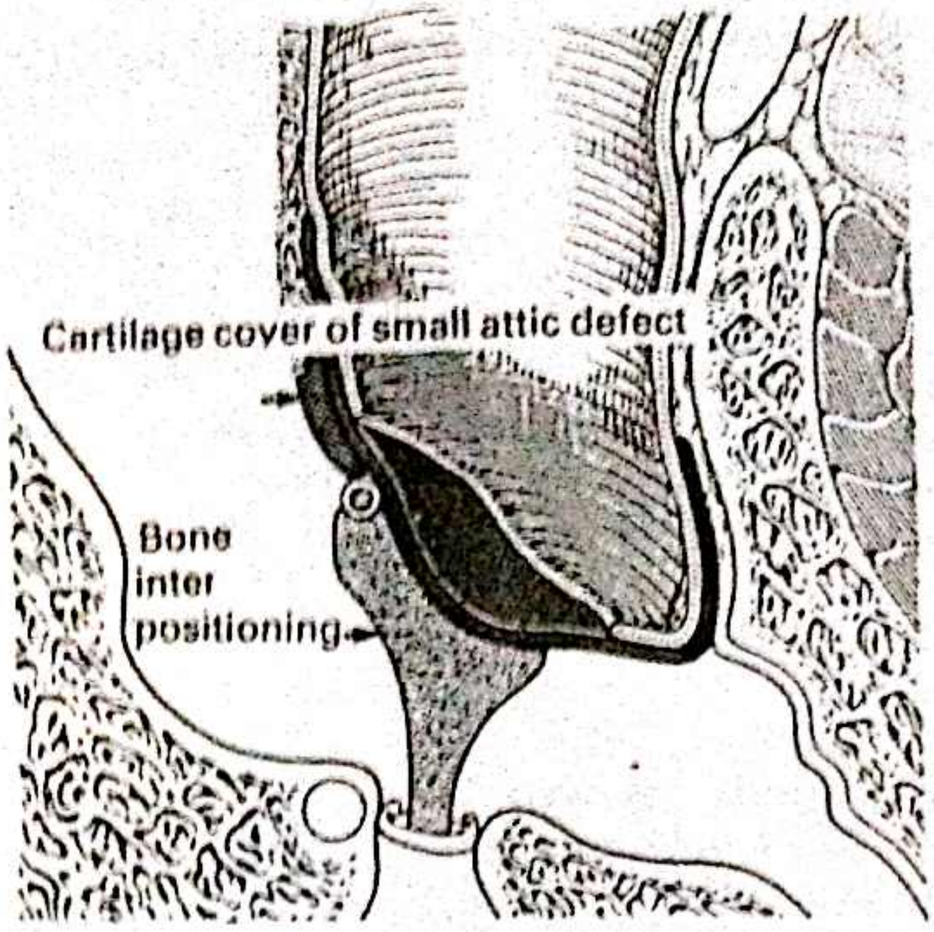
In connection with the reconstruction of the sound-conducting system, the question of staging should be considered. In our experience, in 35 years of ear surgery, pre-planned second-stage surgery does not seem advisable. The patient with cholesteatoma is informed that eventually a second operation will be needed. After surgery, when the drumhead is closed, provided that the patient has a dry ear and is content with the hearing result, there is no reason for further intervention. This means that the repair of the sound-conducting mechanism has been done at the first operation. When the patient's hearing is inadequate, a second operation may be done. Of course there are other reasons for a second-stage operation, but this has nothing to do with a pre-planned second intervention for interpositioning only.

A second look and follow-up should be done in all cases with cholesteatoma, without special regard to the posterior tympanotomy technique. Statistics have shown that recurrent cholesteatoma usually occurs in the tympanic cavity and with retraction pockets. The retraction pocket in particular is a result of inadequate surgery. Unfortunately, reconstruction of defects in the posterior bony canal wall with fascia or other tissue is not usually successful. The use of autologous cartilage for reconstruction prevents retraction pockets almost completely, and is now practised by most ear surgeons.

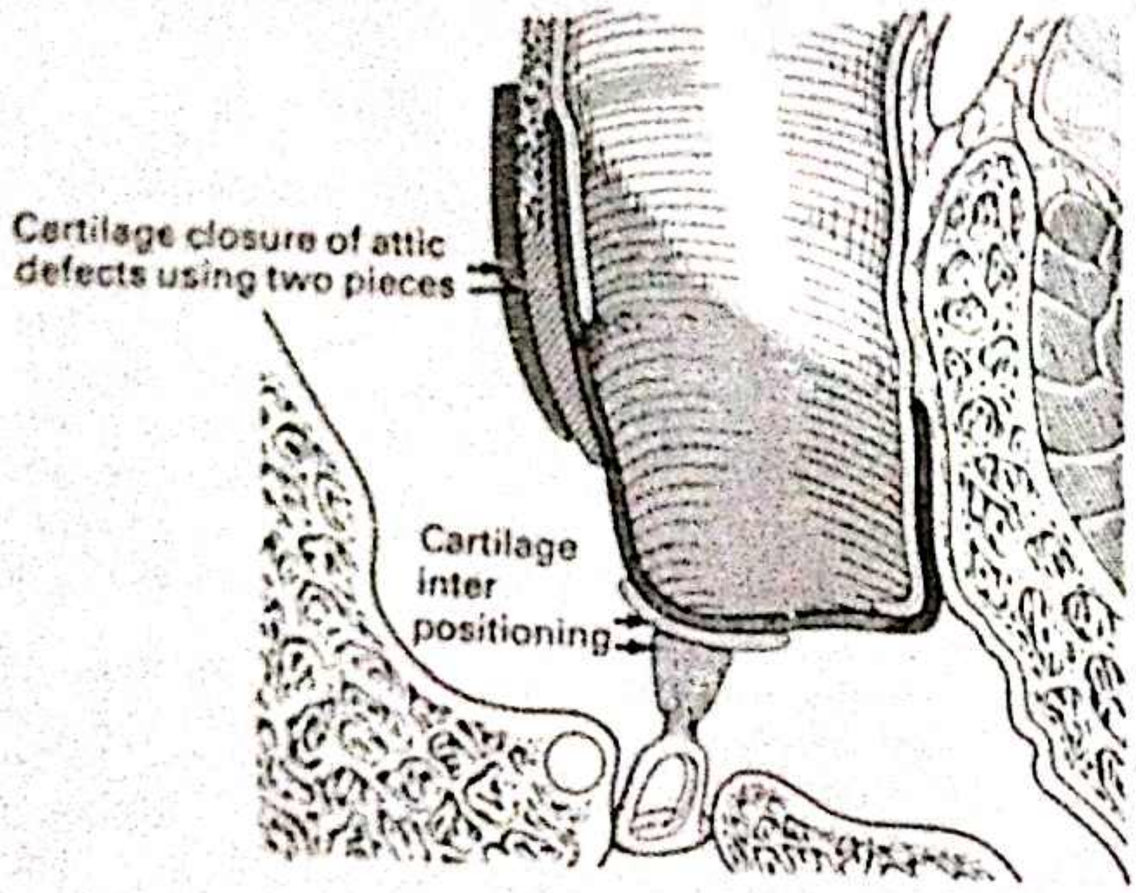
Because of the importance of the potential risk of recurrent cholesteatoma, reconstructive surgery of bony canal wall defects should be explained in detail. Retraction pockets of all kinds have occurred with different techniques of mastoid surgery in connection with tympanoplasty. Posterior tympanotomy was developed as a result of our experience with open mastoid techniques. All defects were left open when the posterior wall had not been taken down completely. When the bridge was left intact a small part of the attic and the bony sulcus remained intact; the skin graft formed a pocket in the region behind the bridge. This region and the lateral blind angle of the open cavity were particularly prone to develop retractions.

17

In posterior tympanotomy all spontaneously and artificially caused defects are closed with one or two layers of autologous cartilage.



17



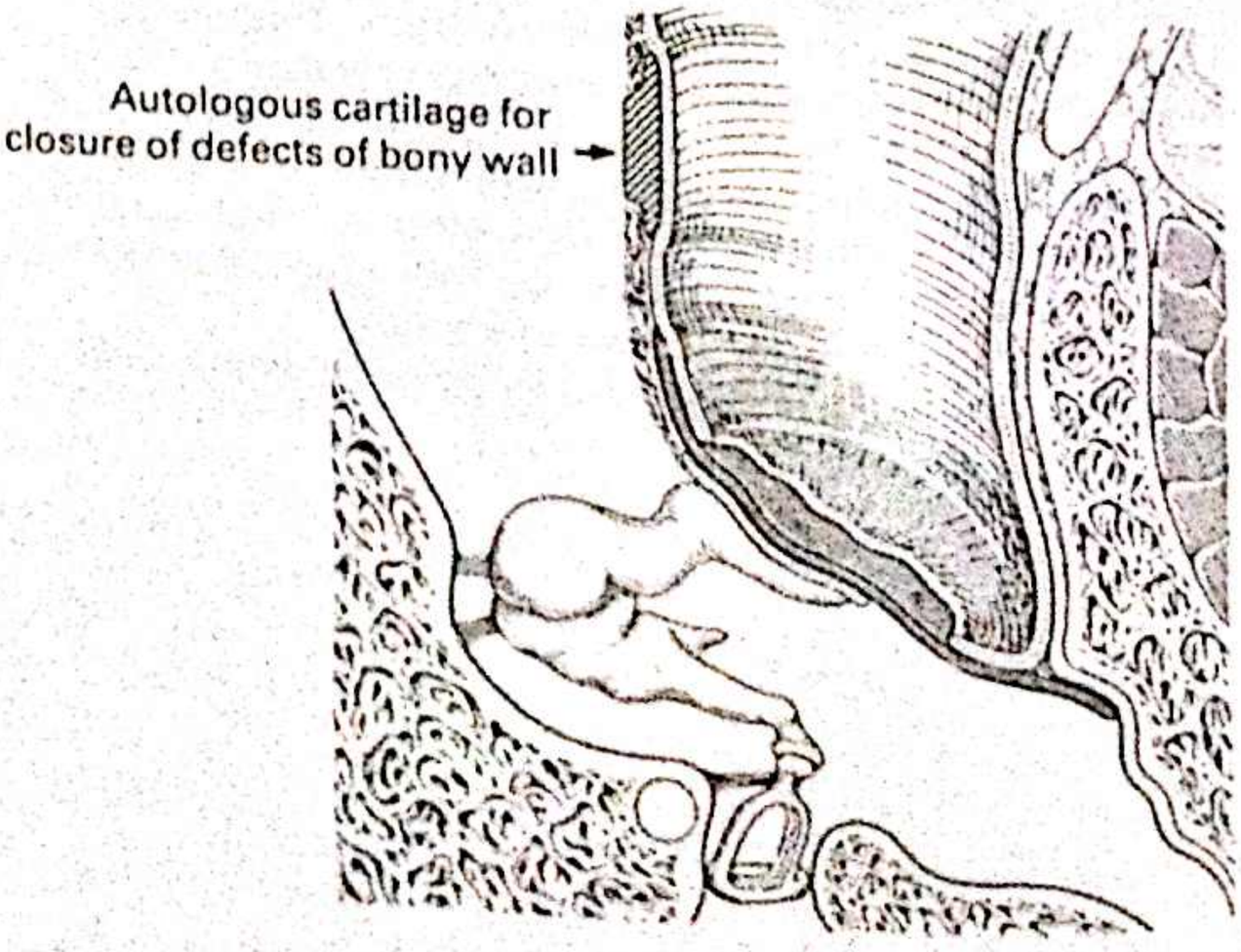
18

18

When the cholesteatoma has destroyed a greater part of the attic, a solid reconstruction is needed.

19

Sometimes the surgeon drills a hole into the posterior bony meatus. These small defects should also be closed.



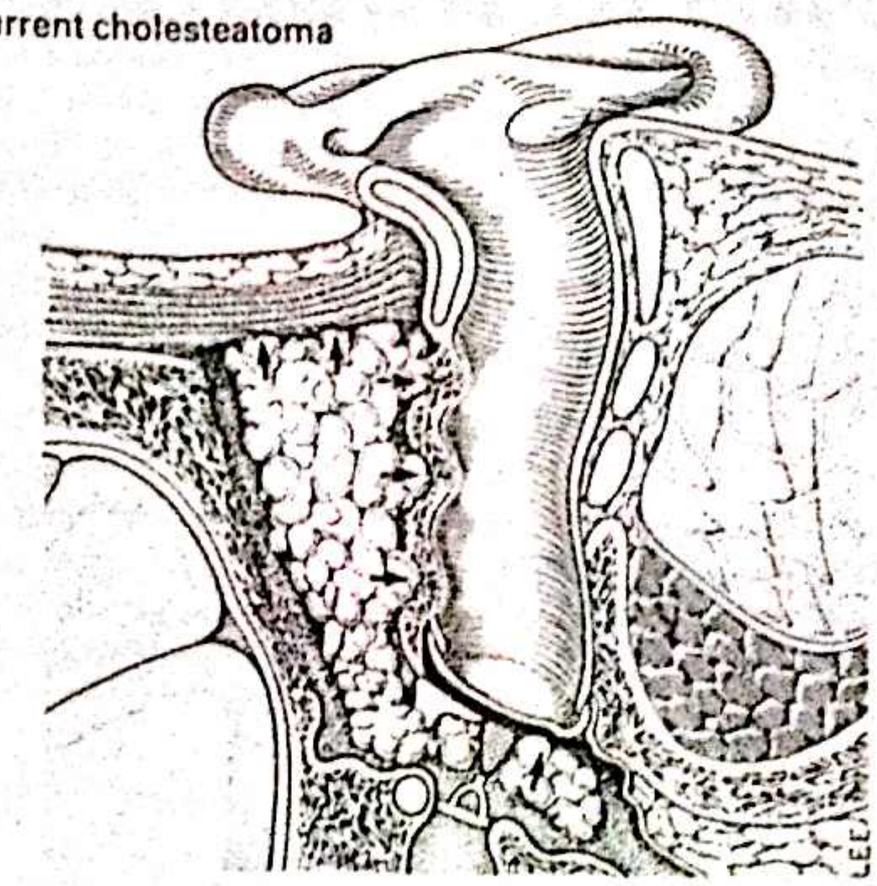
19

When posterior tympanotomy was introduced the question arose as to what would happen when a recurrent cholesteatoma grew up behind the still existing posterior wall. Interestingly, complications are very rare.

20

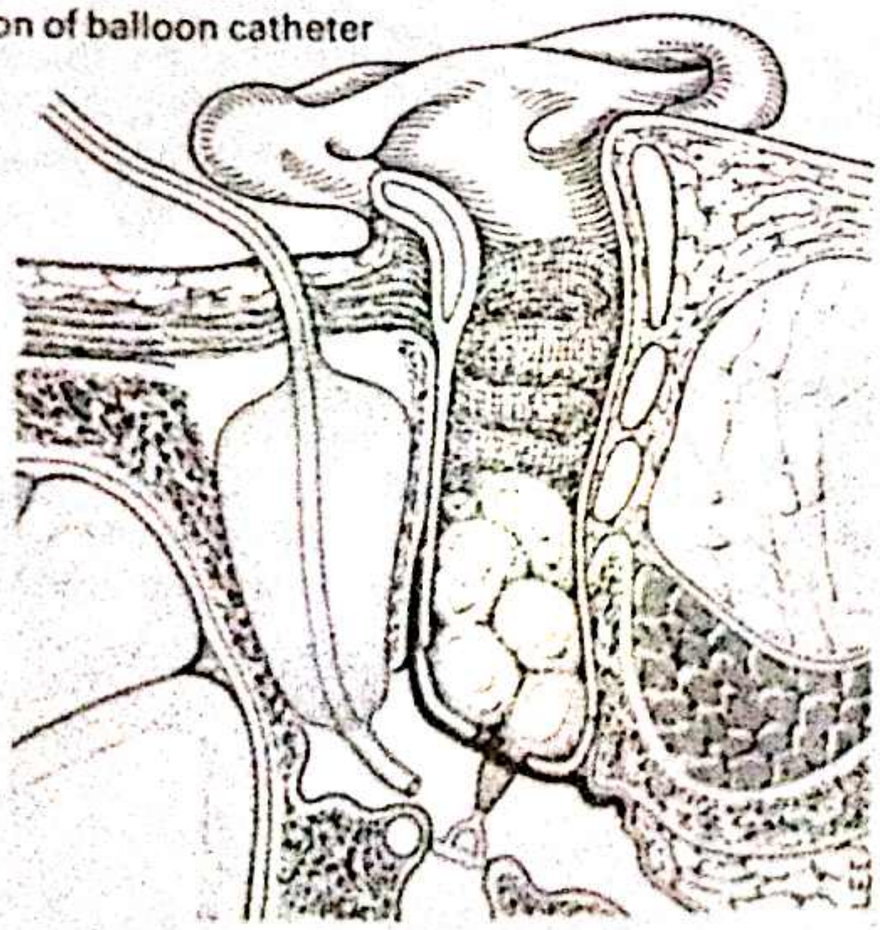
Recurrent cholesteatoma prefers the path of least resistance. There are three regions where recurrent cholesteatoma may occur in posterior tympanotomy. In most cases the thinned posterior bony canal wall is pushed forward and the cholesteatoma can be seen in the meatus or in the open cavity. The other place where a recurrent cholesteatoma might come out is in the postauricular fold, where the cortex has been removed. The most frequent recurrent cholesteatoma comes from the tympanic cavity. Regardless of the procedure performed, remaining small parts of squamous epithelium produce more or less extensive pearls or other kinds of recurrent cholesteatoma. The complete cover of the tympanic mucosa with the matrix is a problem for the surgeon. In most cases the graft is perforated by the disease.

Recurrent cholesteatoma



20

Closure of incision and insertion of balloon catheter



21

The question of what to do with a case of recurrent cholesteatoma has been discussed very often. So far no perfect solution has been found. It is up to the surgeon to decide on the procedure of preference. In our experience, partial or total reconstruction of the meatus with autologous cartilage has been found to be very successful. The bent portion of the cartilage of the auricle is taken by a posterior incision. The perichondrium layer should be left intact because it is most important for nutrition.

21

A small urogenital balloon catheter is inserted and filled with sterile solution. The catheter allows suction as well as infusion; for example, of low concentrations of antibiotics.

Postoperative treatment

The gauze strip and gelfoam, if they remain dry or become dry, should stay in the meatus for 2–3 weeks. The gauze strip should be changed if it becomes wet and starts to smell. General antibiotic treatment is recommended for about 10 days. Microscopy follow-up is needed.

Illustrations by Liddy Abes, Robert N. Lane and Gillian Lee

Allografts in tympanoplasty and other forms of middle ear surgery

J. F. E. Marquet MD
Professor and Chief, Department of Otorhinolaryngology, University of Antwerp, Belgium

Introduction

The use of preserved allografts for tympano-ossicular reconstruction has been a major advance in middle ear surgery and has opened exciting new and clinically proven possibilities. Through further development in surgical techniques it is now possible to achieve the main goals of this kind of surgery: total eradication of the underlying pathology; a long-lasting anatomical restoration of the middle ear cavity; and good functional results.

Indications

Tympanic, ossicular or tympano-ossicular allografts may be used in any case of chronic middle ear disease requiring reconstructive ear surgery and in the treatment of congenital malformations of the ears. The drum, or tympanum, may be used alone (HT) or with the malleus attached (HTM) for partial replacement, or together with the articulating ossicles, the incus (I) and stapes (S), as a total replacement graft (HTMIS). Individual autologous ossicles can be used to replace an absent one by direct insertion into the correct anatomical position or by modification and placement anywhere in the interrupted chain.

The advantage of these techniques is that the shape of the allogenous ear drum or tympano-ossicular chain allows exact topographical positioning and thus perfect anatomical restoration in nearly every case.

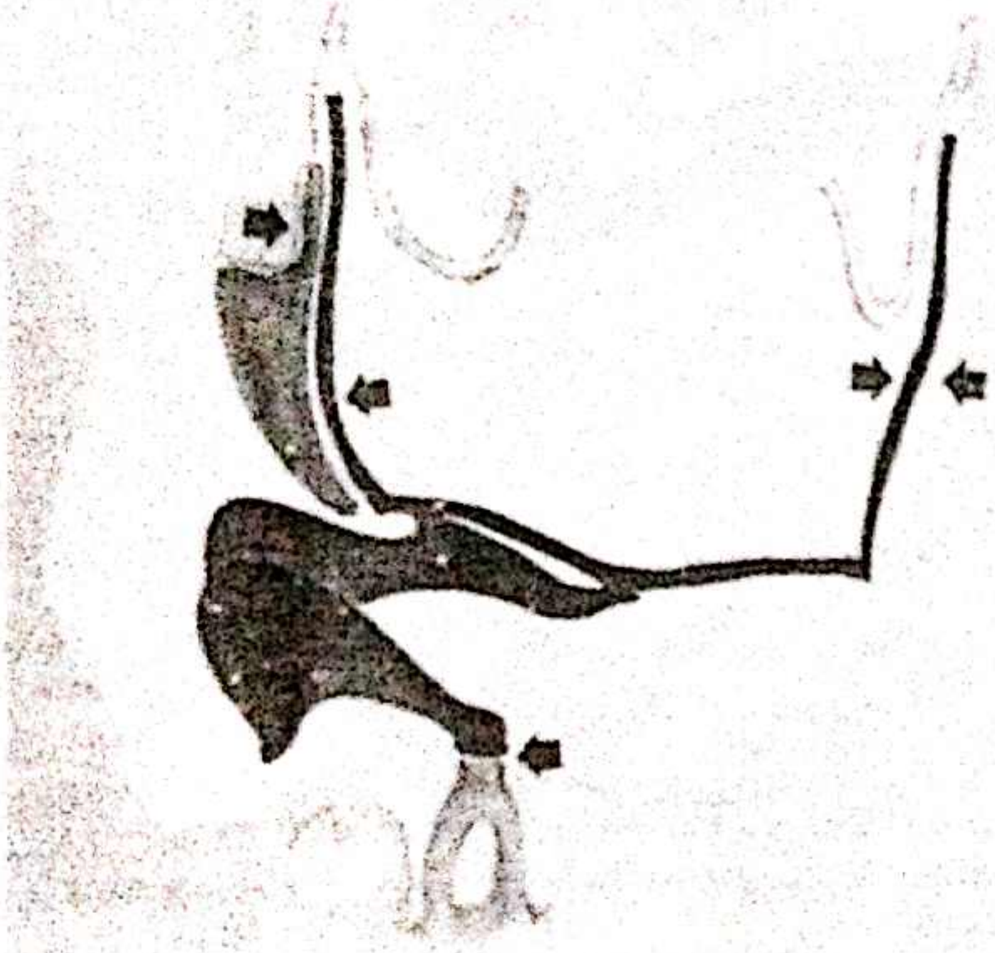
Contraindications

The only formal contraindications to such surgery are acute purulent infections or, more rarely, specific infections of the ear (e.g. tuberculosis) and carcinoma.

General principles of grafting

Clinical experience as well as experimental studies have shown the following principles as essential to success in this type of surgery.

1. Only the lamina propria and fibrous annulus of the tympanic membrane are used, including the neighbouring meatal periosteum. The host's fibrous annulus or drum remnants should always be removed and replaced by an allogenous fibrous annulus, which must be placed carefully on the bony annulus.
2. Since the attachment of a vibrating membrane to the rigid ossicles is always the weakest point in the repair, it is preferable, when the malleus must be removed, to use a monobloc tympano-ossicular implant. The preservation of a genuine fixation of the drum to the manubrium is one of the main advantages of this technique. So far, no other surgical technique has been able to copy or to restore this structure successfully in the long term.
3. Natural joints fixed in formaldehyde or glutaraldehyde and then preserved in Cialit (Asid-Institut, W. Germany) always function satisfactorily, and are therefore preferable to any other substitute.
4. The survival of the ossicles, as regards maintenance of their shape and new bony formation, depends on the condition of the mucoperiosteum. For this reason modelling of the ossicles must always be kept to a minimum.
5. Correct anatomical positioning of the graft is essential and is facilitated by the conical shape of the preserved drum. A misplaced drum annulus or tympano-ossicular chain will never give a good result.
6. A correctly positioned allograft ossicular chain with its tendons and ligaments re-establishes continuity with the remnants of the host's tendons and ligaments and thus allows anatomical and physiological restoration of the middle ear.



1

The recent introduction in ear surgery of an efficient biological adhesive (Tisseel; Immuno, Austria), which is a non-toxic resolvable fibrinogen glue, has greatly improved the technical possibilities of this type of surgery. The common sites of application are shown (arrows).

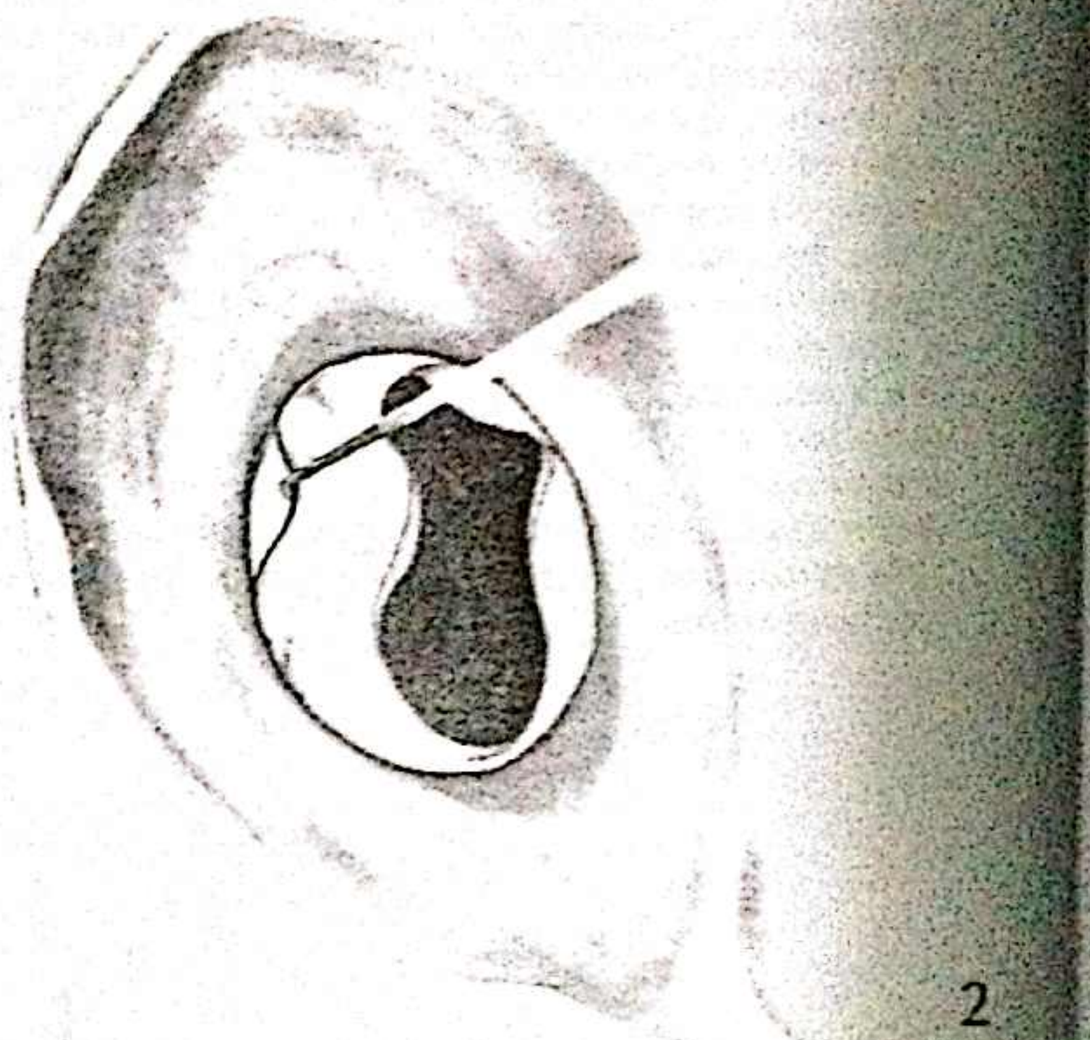
Temporal bone bank

A temporal bone bank is obviously necessary to perform this kind of surgery. This requires a suitable source of donors and careful attention to removal and preservation of drum and ossicles.

Collection of transplant material

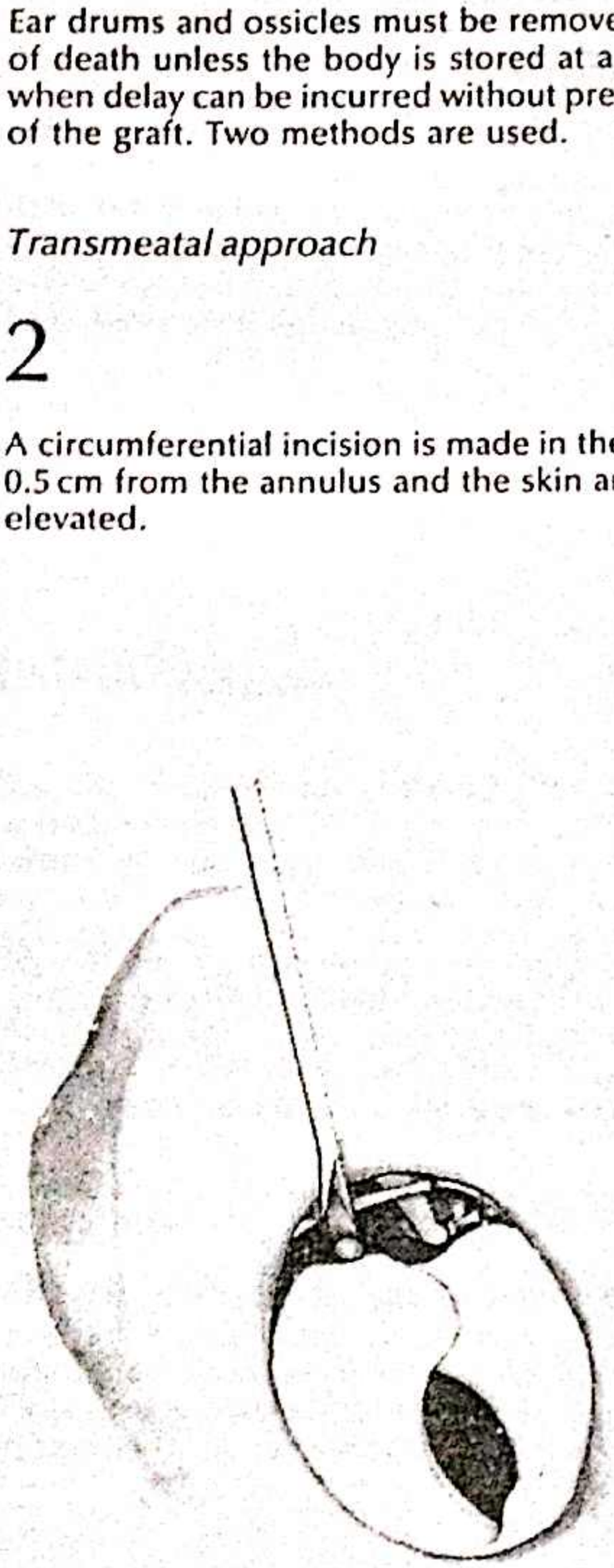
Ear drums and ossicles must be removed within 12 hours of death unless the body is stored at a low temperature, when delay can be incurred without prejudicing the safety of the graft. Two methods are used.

Transmeatal approach



2

A circumferential incision is made in the deep meatal skin 0.5 cm from the annulus and the skin and periosteum are elevated.



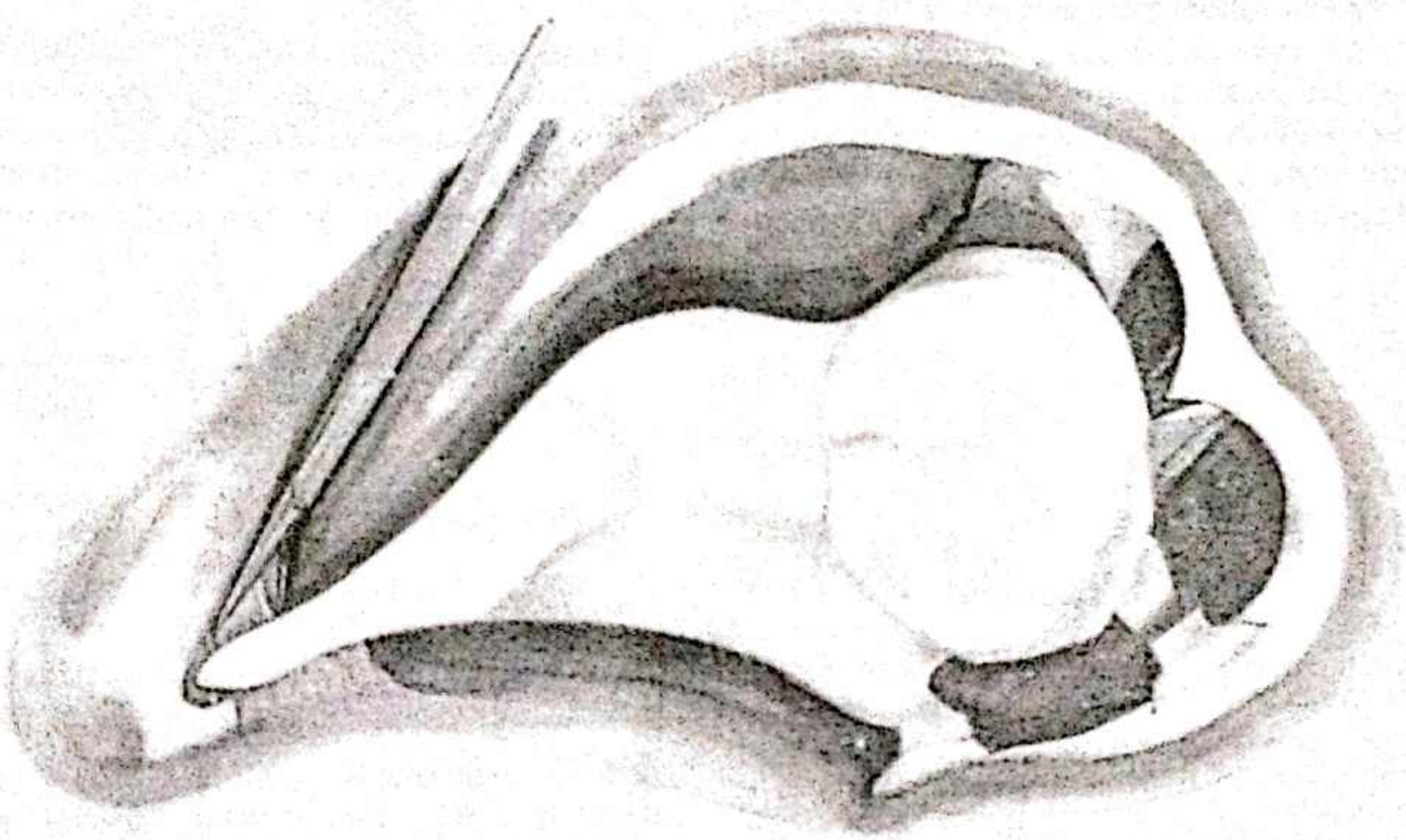
3

Once the annulus has been freed, the tensor tympani, mallear ligaments and chorda are divided in succession. Only drum or tympano-mallear graft can be obtained by this route.

Transcranial approach

4

The transcranial route is the only way to obtain a complete tympano-ossicular chain which can be used as a total replacement graft (HTMIS). The temporal bone is removed with an oscillating circular saw, as in Schuknecht's technique. The meatal skin, annulus and drum are dissected as in the transmeatal approach (*see Illustrations 2 and 3*). The anterior and posterior mallear ligaments, the chorda tympani and the stapedius tendon are then successively divided.

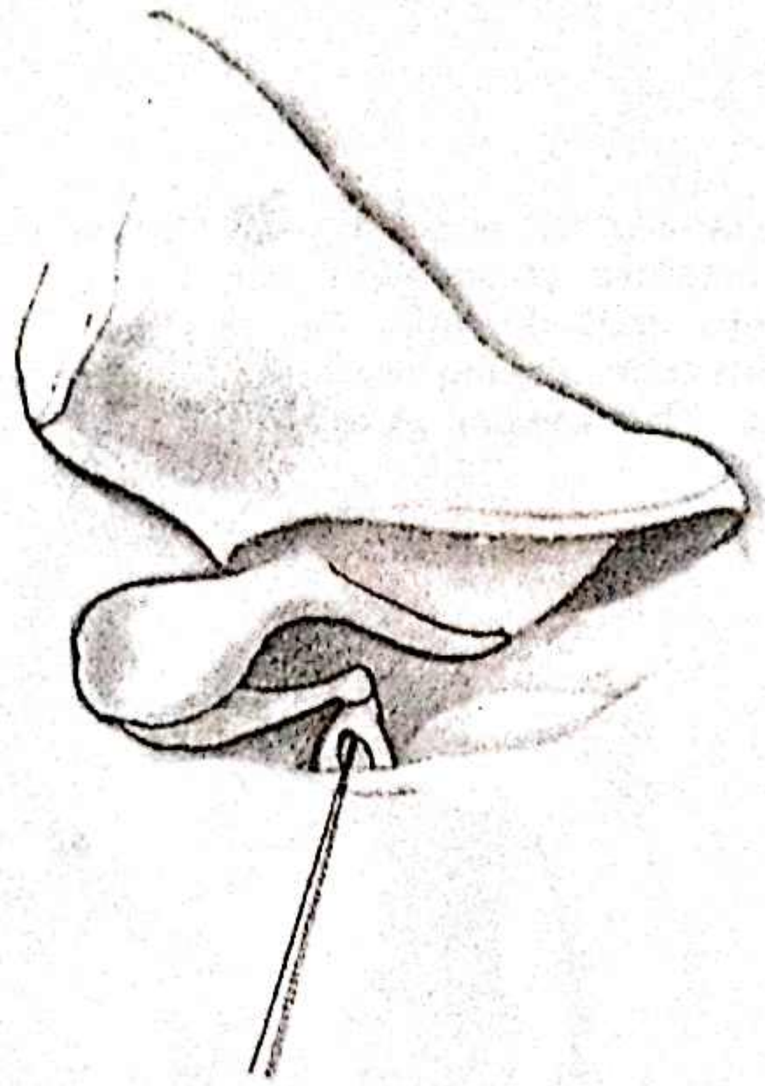


4

5

The tegmen tympani is then opened from above, and the superior mallear ligament and incudal ligaments are divided.

6



The attic wall is removed and the stapes is gently elevated so that the whole ossicular chain, together with the drum, can be freed.

6

Preservation of transplant material

Immediately after removal the tympanic graft or temporal bone is fixed in a solution of 4 per cent formaldehyde buffered to a pH of about 5–6 with a sodium acetate/acetic solution. Glutaraldehyde has also been used for this purpose.

After fixation for 2 weeks in this solution, the allograft is dissected out and washed. It is then transferred to a 1:5000 aqueous solution of Cialit (a sodium salt of an organomercuric compound). This ensures not only preservation of morphological structure but also sterilization and immunological inactivation of the tissue, and avoidance of the risk of ototoxicity. Moreover, the combined use of formaldehyde and Cialit allows the tissue to retain its normal suppleness, which is not possible with formaldehyde alone, and makes survival after surgery more likely than when the graft is preserved in Cialit alone.

The grafts are kept in the Cialit solution at a temperature of between 1 and 2°C, and bacteriological checks are carried out regularly. The storage time in Cialit should never exceed 2 months. Tympanic or tympano-ossicular implants prepared in this way may be considered as immunologically inert.

Although minor reactions, e.g. 'smooth immunological reactions', have been reported, no major antigenic phenomena have been observed.

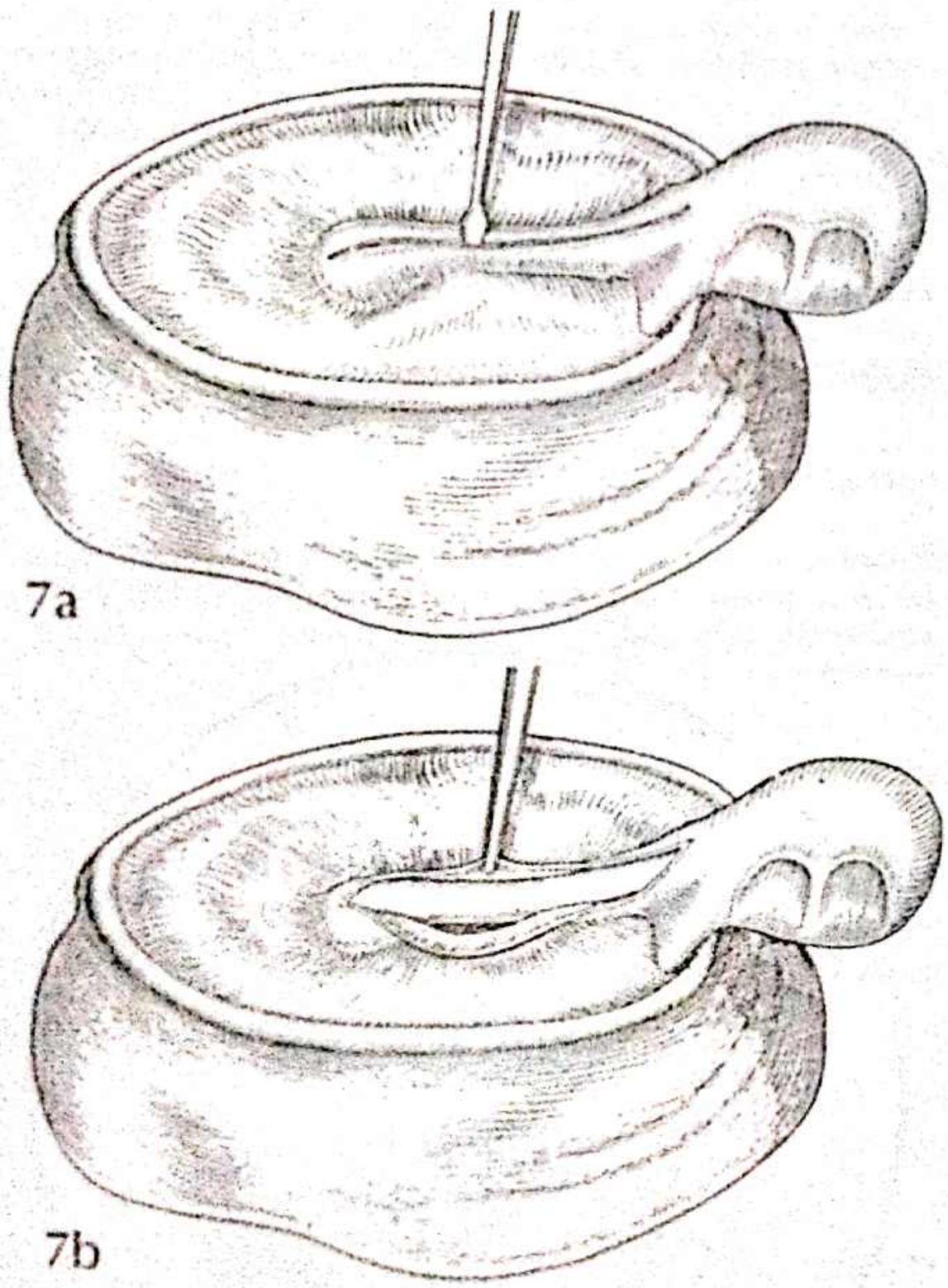
Preoperative

Preparation of graft

A final rigorous inspection is made of the selected graft. Ears obtained from those dying from generalized carcinoma, viral infections or other unkown diseases must be excluded. Bacteriological examination should also be repeated before the operation.

Tympano-ossicular graft

After preservation for 2 or 3 weeks in Cialit, the squamous epithelium of the tympanic membrane and meatal skin is easily elevated by means of suction. The meatal sleeve is usually cut 8 mm from the annulus, the mucosal remnants are elevated from the annulus, and the tensor tympani, stapedius tendon and anterior and posterior mallear ligaments are preserved with the graft. The mucoperiosteum of the ossicles is always preserved.



7a

7b

Ossicular graft

Ossicles are preserved separately, and also according to size and side. Again, the mucoperiosteum has to be preserved. When ossicles have to be modelled during surgery, drilling should be kept to a minimum. All ossicular implants should be handled carefully. Extensive remodelling, particularly by drilling without a cooling irrigant, may prejudice the graft's survival by either burning the bone or mechanically disrupting its structure.

Tympanic graft

7a & b

When only a tympanic graft is to be used the malleus has to be dissected free from the tympanic membrane. This is best done with a small knife, cutting the mucoperiosteum of the handle of the malleus down from its medial aspect throughout its whole length (*a*). The mucoperiosteum is then gently dissected so that the whole membrane becomes free from the handle of the malleus (*b*). The dimensions of the graft are recorded. The most important one for tympanoplasty is the distance between the umbo and inferior margin (4.2 ± 0.8 mm).

Preparation of recipient ear

The correct ear is assessed and prepared by the suction technique, supplemented by medical therapy if required. Particular attention is paid to cleaning of the meatal skin and tympanic remnants.

Anaesthesia

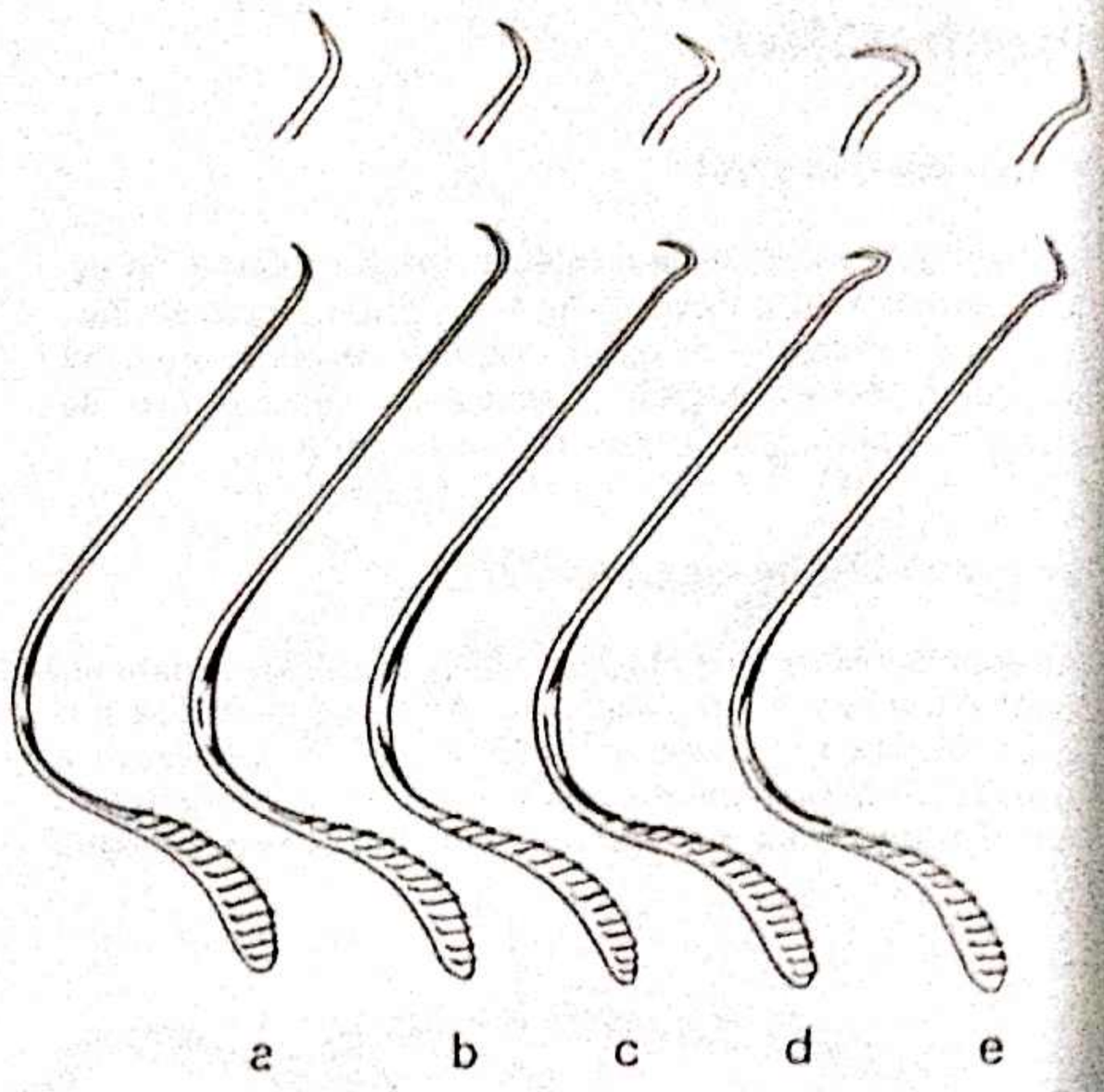
The technique and type of anaesthesia are important because both can affect the final result. For example, displacement of the graft may be due to the use of nitrous oxide, which causes an increase in pressure in the middle ear. The anaesthetic technique must also avoid sudden changes in the patient's autonomic system during, immediately after, or several hours after surgery. The patient should recover gradually from the anaesthesia so that he does not cough or vomit.

The operations

Instruments

8

A special set of instruments has been designed: right and left sickle knives, vertical knives and three elevators set at angles for easier elevation.



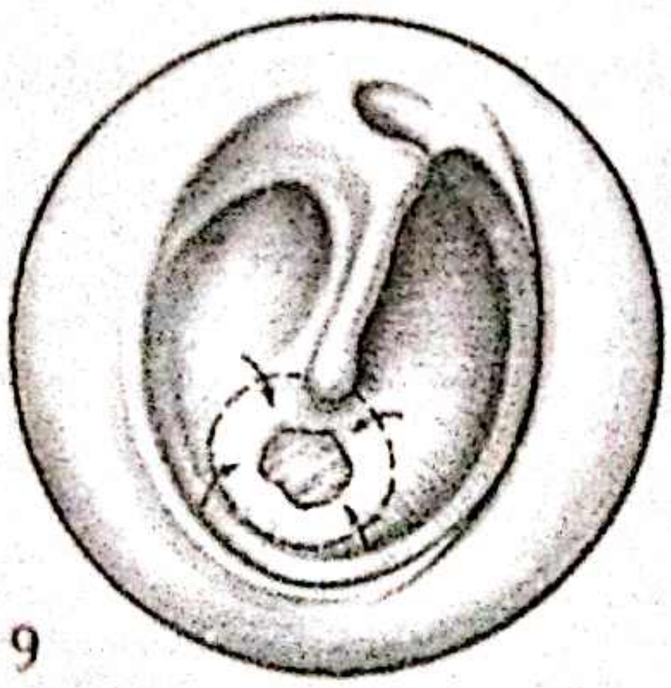
8

Choice of procedure

TRANSMEATAL APPROACH

Partial myringoplasty

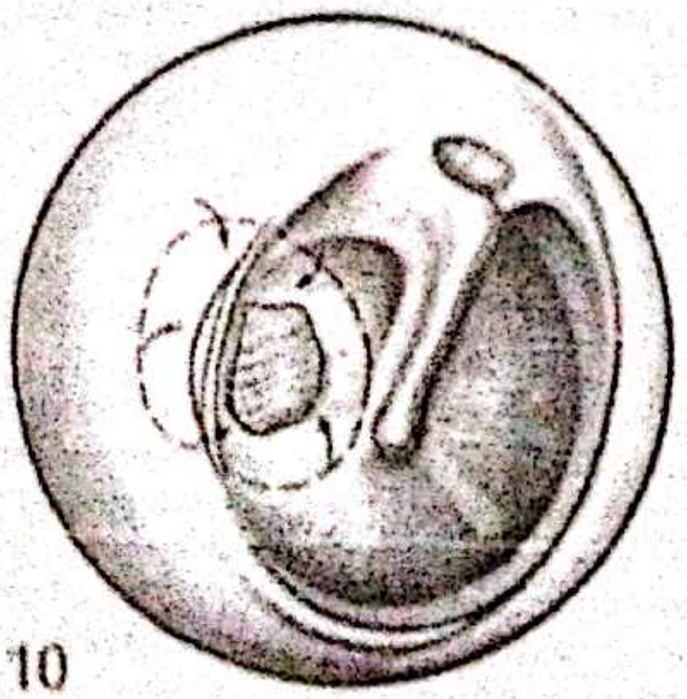
Partial restoration of the tympanic membrane should only be undertaken in selected patients when the middle ear is absolutely safe and when only a partial restoration is needed.



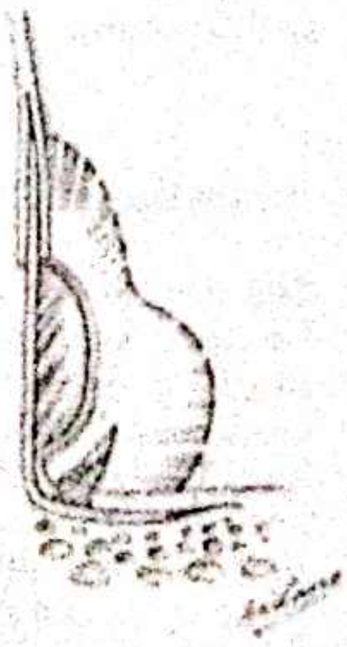
9

9

Some defects require only a piece of preserved tympanic membrane inserted between the elevated squamous epithelium of the drum and its pars fibrosa.



10



10

Others may have to be repaired by inserting a fragment of fibrous annulus and meatal skin attached to a fragment of tympanic membrane.

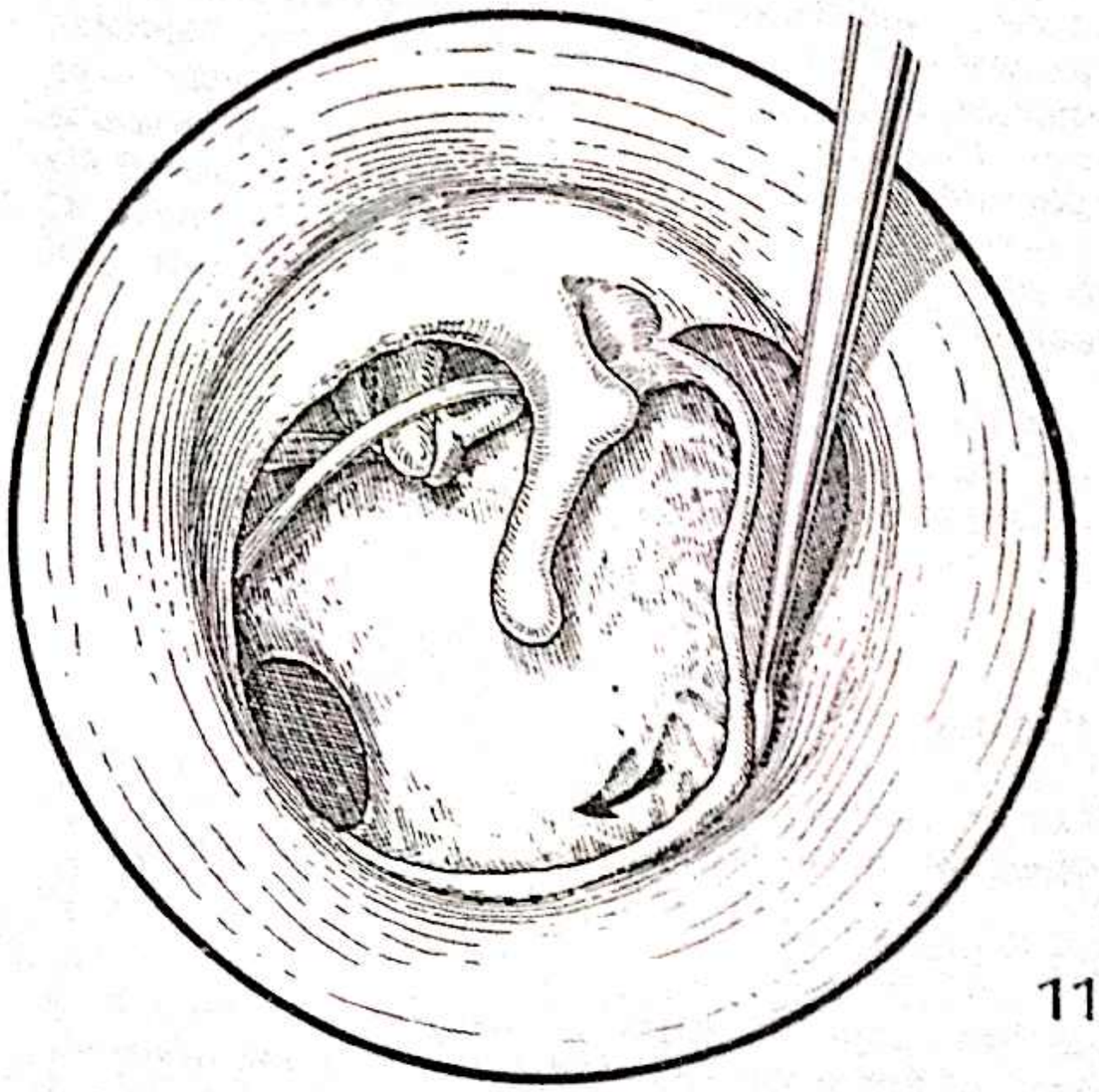
Total myringoplasty

A total myringoplasty may be occasionally performed by the transmeatal route when the ear is free from infection but there is a perforation and an adhesive process. Some ossiculoplasties may also be undertaken by this route.

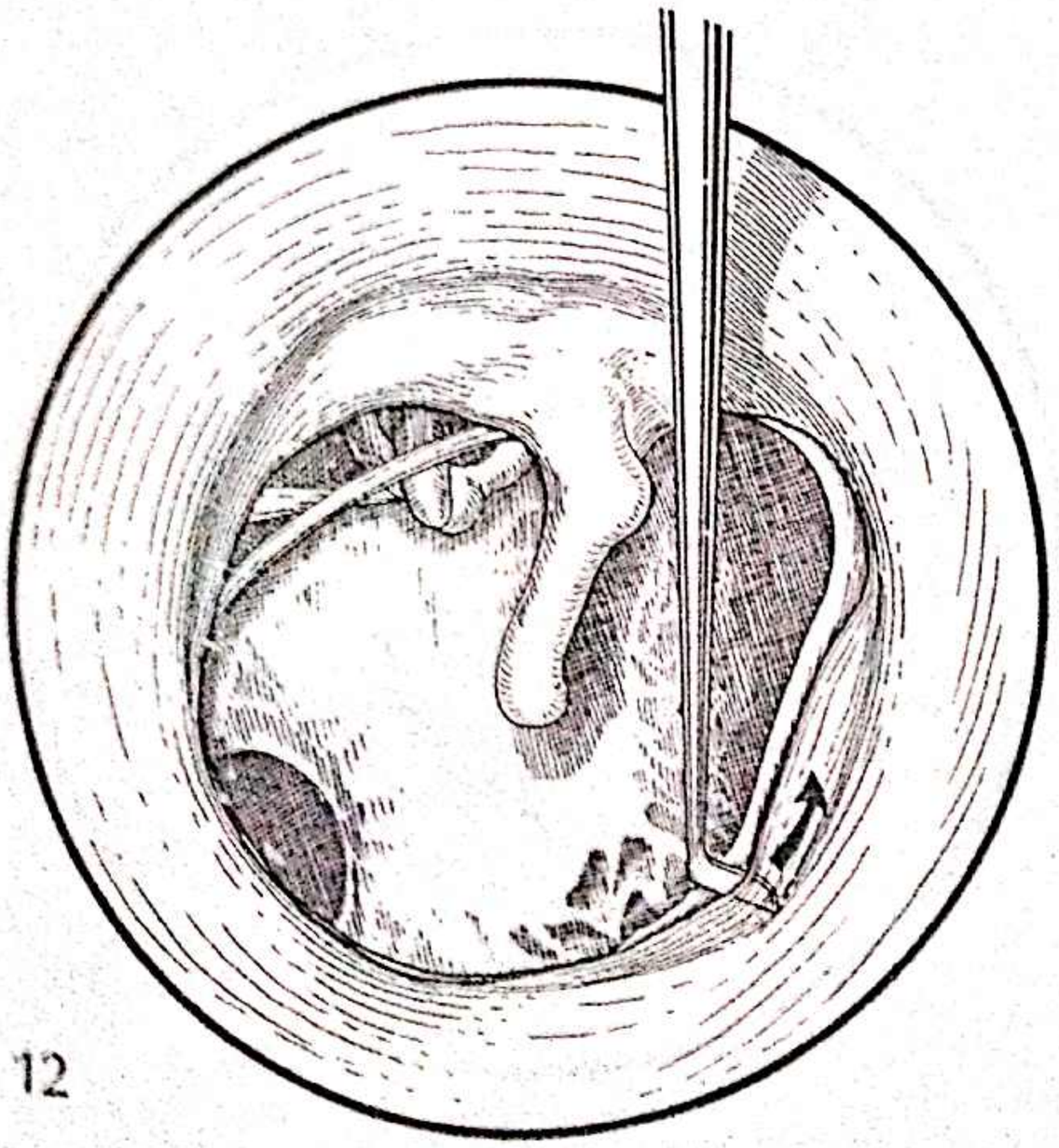
11, 12 & 13

Using a vertical knife, all scar tissue is first removed from around the whole circumference of the perforation. Starting at the edge of the perforation, the outer epithelial layer is carefully dissected from the fibrous layer towards the periphery, using specially designed sickle knives and elevators. The dissection is carried laterally from the bony wall for about 1 cm from the annulus. The host's fibrous annulus and remnants of lamina propria are then removed. If any tympanosclerosis exists, this too is totally removed.

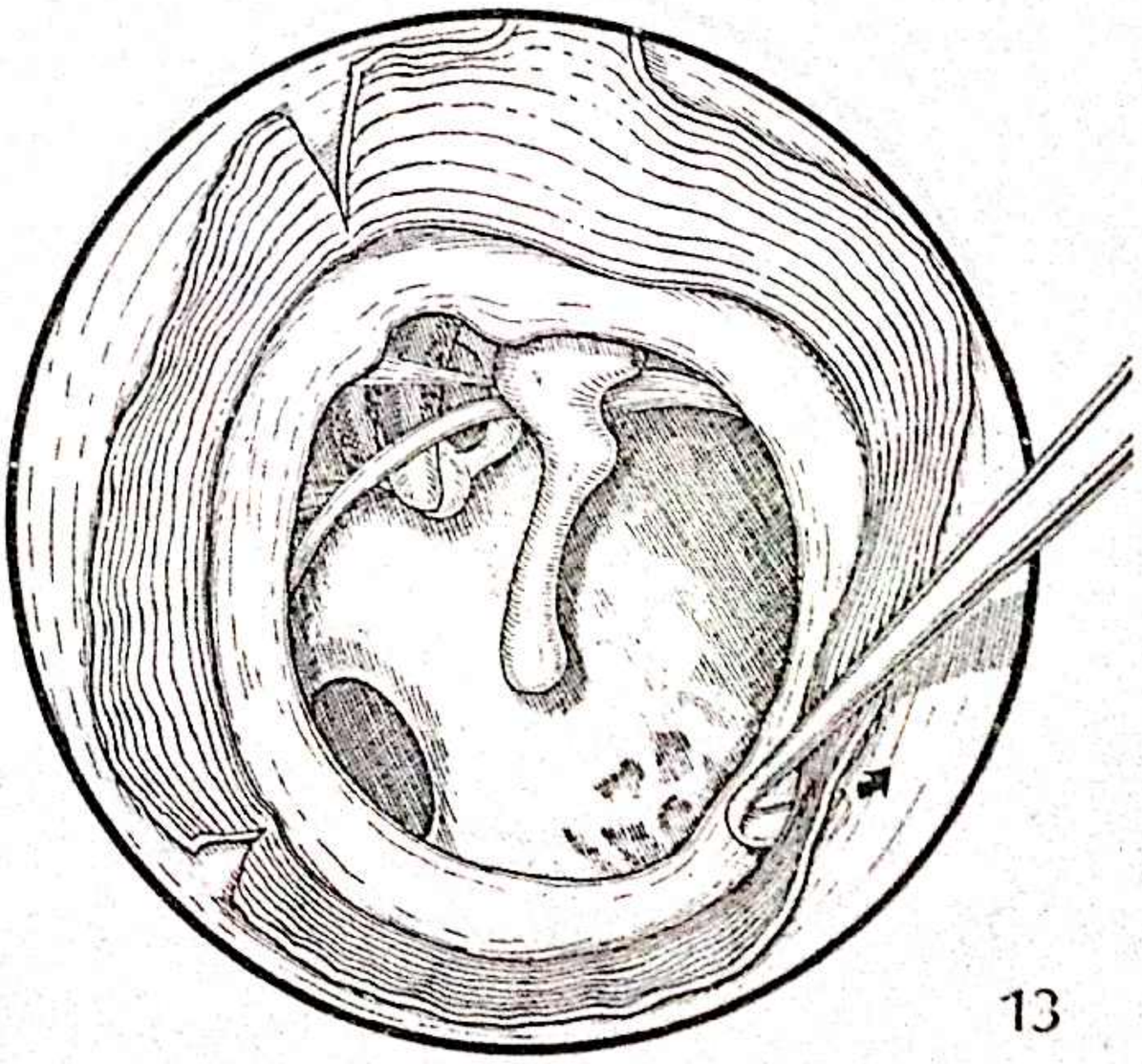
When all epithelial remnants of the drum, together with the meatal skin, have been retracted outwards through the auditory canal, the integrity of the ossicular chain is checked. If any restoration is required this may be carried out at this stage. Special care is taken to ensure that all epithelial remnants have been removed, in particular from the entire bony sulcus and from the handle of the malleus and umbo.



11



12



13

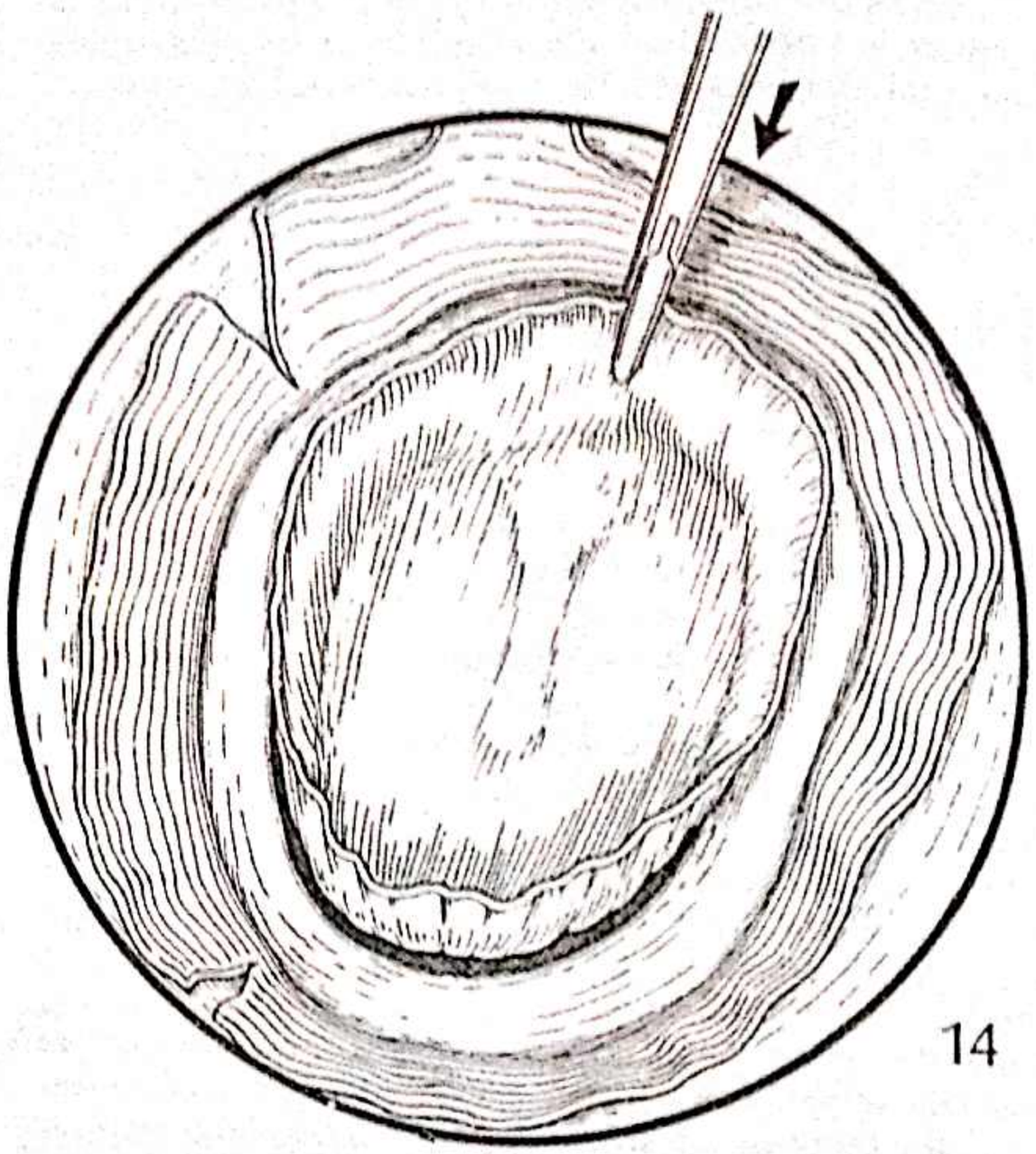
14, 15 & 16

An allograft drum of correct size and shape is then introduced and placed in position, taking great care to align it correctly. The sheath of allograft material which has been separated from the donor's handle of the malleus is aligned with the denuded handle of the host's malleus, and the conical shape corresponds to the short process of the malleus with the short process of the host's malleus. A drop of biological glue can be used at this stage (see *Illustration 1*). As the meatal cuff of the tympanic allograft is glued and pushed against the bony wall of the auditory canal, the annulus automatically assumes its correct postion and is glued into place with biological adhesive (see *Illustration 1*).

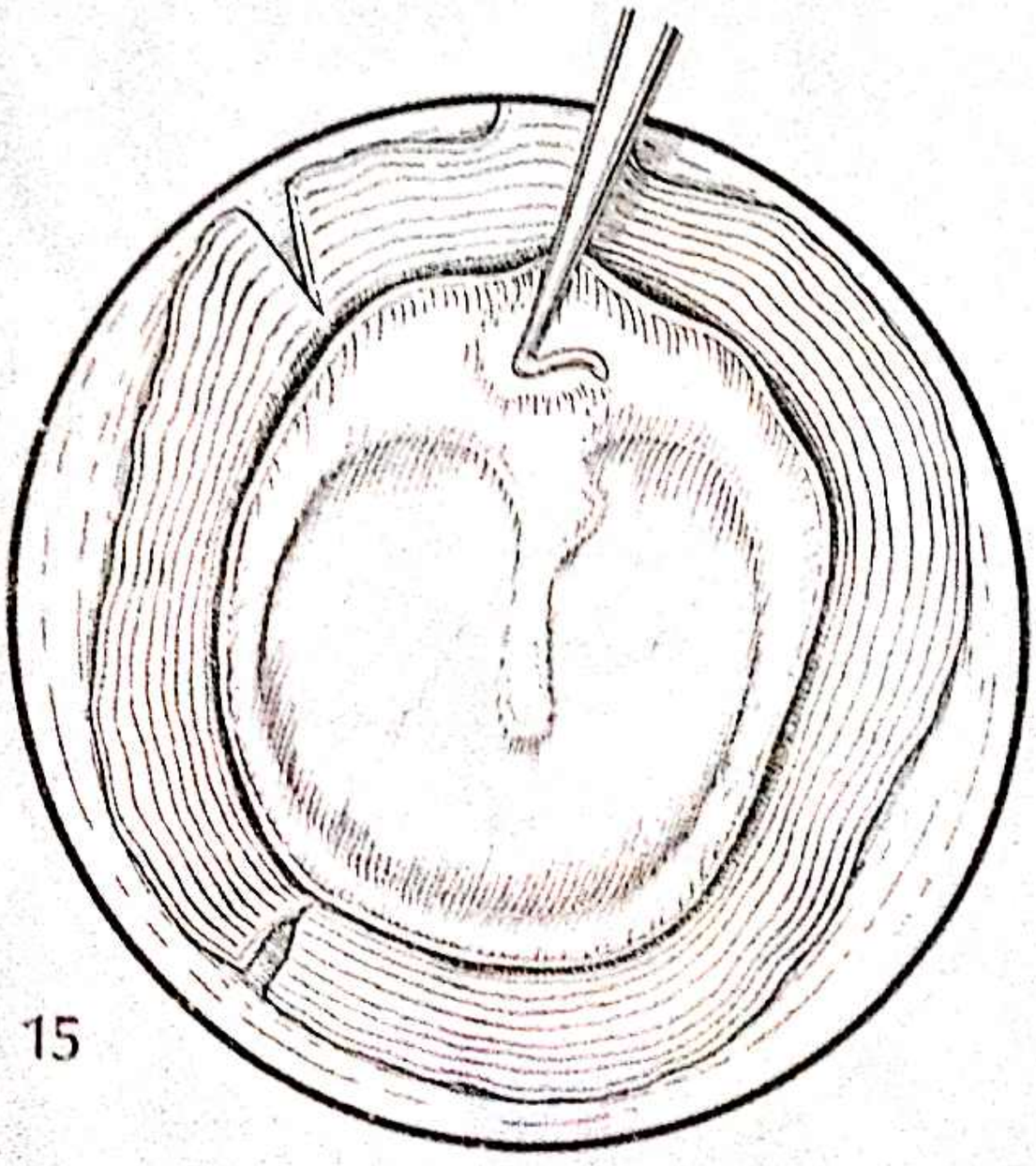
The previously elevated epithelial remnants of the drum and the skin of the auditory canal are replaced on the surface of the periosteal cuff, taking care to avoid any rolling of the epithelial layer, which could cause postoperative epithelial pearls.

Packing

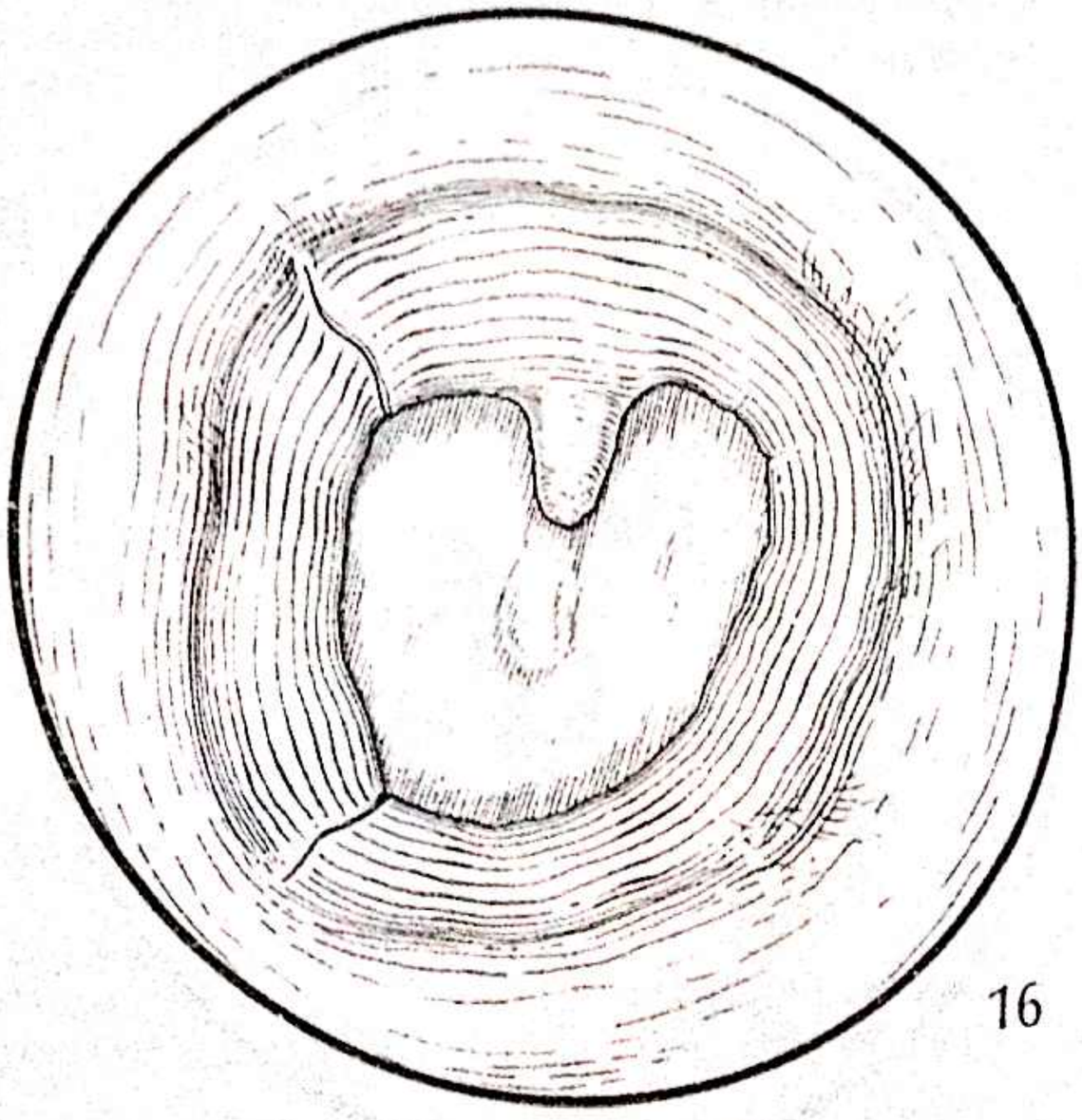
Correct packing is essential to ensure success of the operation and is described in detail on page 124.



14



15



16

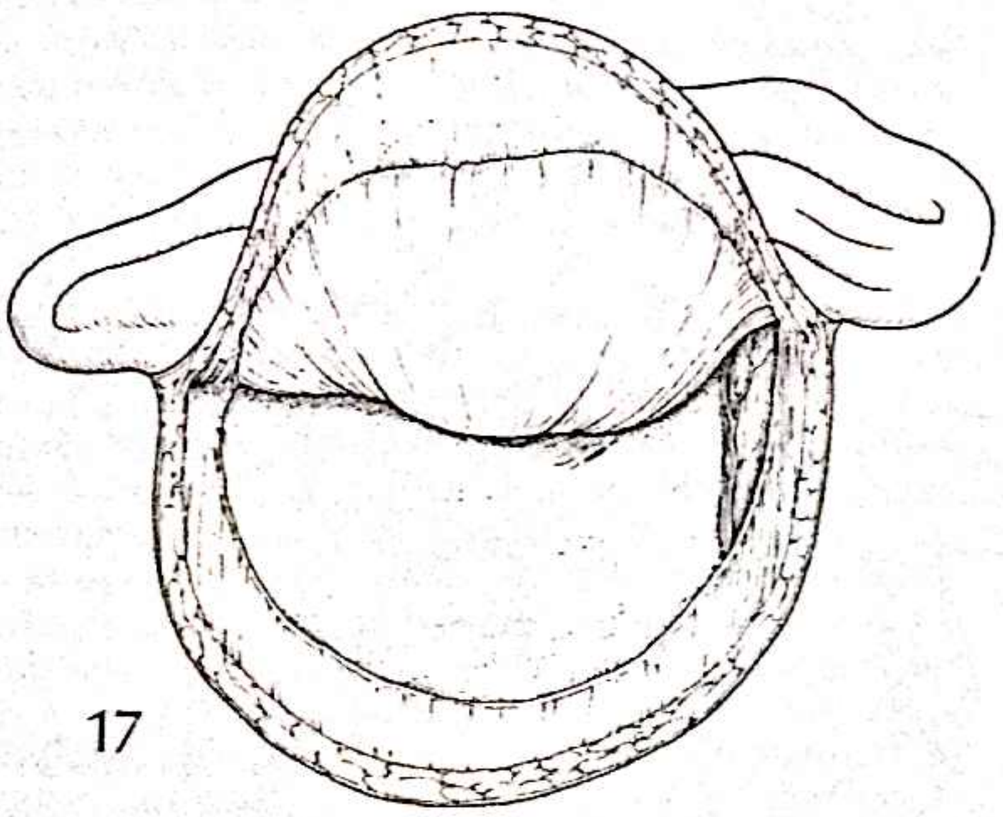
POSTERIOR APPROACH

Except for the few cases in which the transmeatal route may safely be used (see above), the posterior route is usually preferred. It is used in more than 95 per cent of our cases for chronic ear disease, even when the extent of the pathology is uncertain, and is recommended whether the canal wall is to be left up or taken down. This approach has several advantages:

1. The meatal skin is removed in a 'finger-like' fashion, without prejudicing its blood supply.
2. The middle ear incisions are separated from the incision through the skin and periosteum.
3. The eventual opening of the mastoid will always be covered by periosteum.
4. Retroauricular blood and especially air drainage will always be possible posteriorly, without disturbing the middle ear packing.

Instrumentation

Apart from the usual instruments required for posterior tympanotomy, a specially designed elevator for the removal of the skin of the auditory canal (*see Illustration 18*) has been found helpful.



17

The incision

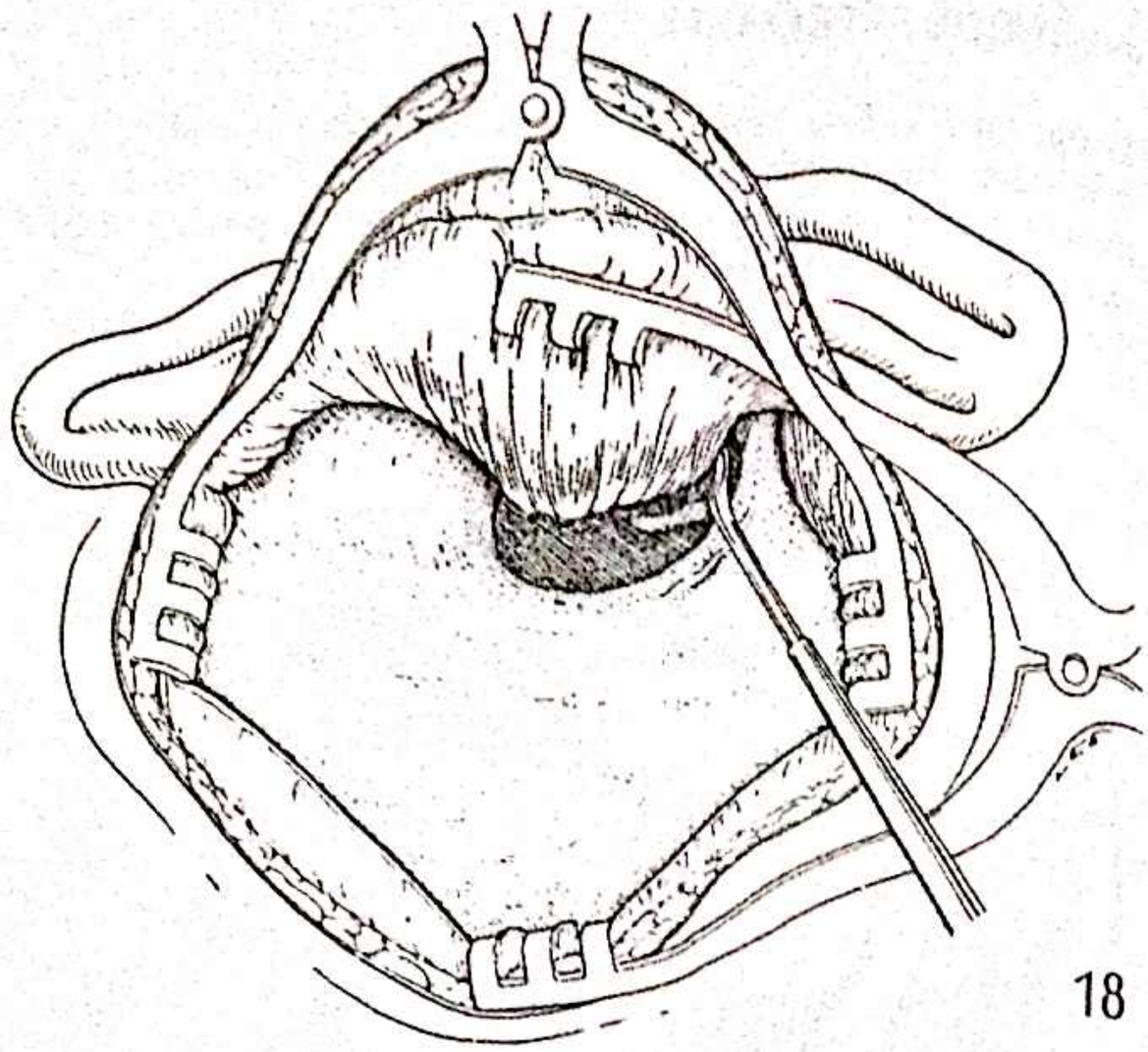
17

A postauricular incision is made through the skin approximately 3 cm from the groove and turned forwards. The periosteum is then incised a few millimetres anterior to the skin incision and elevated forwards to the meatal wall. Two flaps are thus obtained, one of skin and the other of periosteum.

18 & 19

The retractors are now positioned and the meatal skin is completely dissected from around the auditory meatus towards the bony annulus, elevating the entire fibrous annulus. Using the specially designed elevator, the whole cuff of skin can be lifted in a finger-like fashion and rolled outwards through the meatus so that the bony meatus is completely free of soft tissue. The annulus and drum remnants are elevated and removed (*see Illustration 25*).

A plastic sponge is put in the meatus to maintain the position of the skin anteriorly and to protect the middle ear from bone dust.



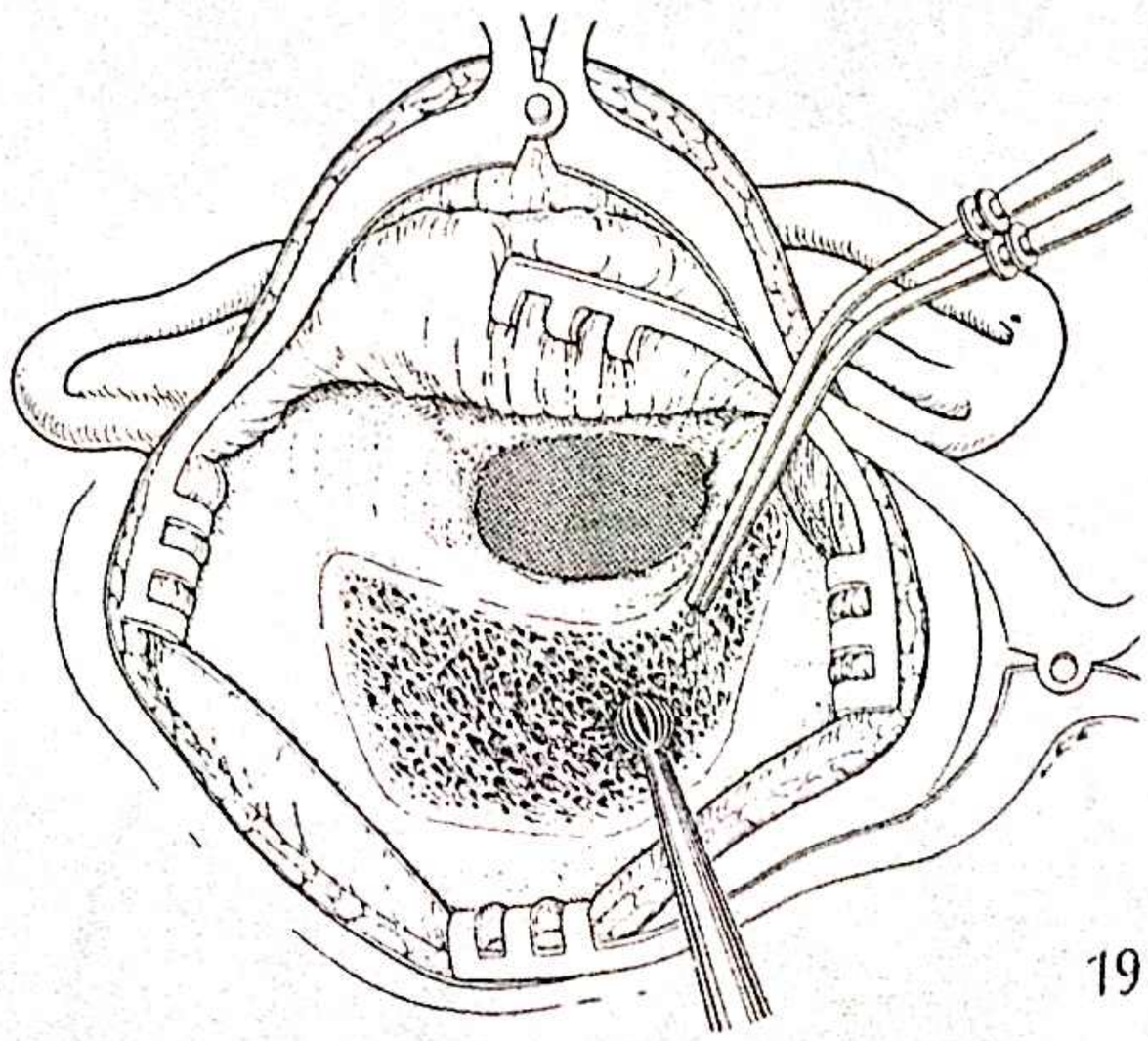
18

Simple myringoplasty

When the pathology seems safe and all tympanic and annular remnants have been dissected from the ossicular chain, assuming that this is intact or that only simple ossiculoplasty has been performed, a tympanic membrane surrounded by its cuff (HT) is all that is needed.

A tympanic membrane of suitable size and with its periosteal cuff attached is selected and put into place. The sheath of the donor's manubrium must be placed exactly on top of the host's manubrium to ensure correct anatomical resetting of the drum. Fibrinogen glue is used to fix the manubrium to the drum, the fibrous annulus into the sulcus, and the meatal cuff of the allograft to the bony edges (*see Illustration 1*).

The retractors are then removed and, using the transmeatal route, the previously elevated skin is gently repositioned on top of the graft, taking particular care that no blood or air is trapped between the graft and the skin remnants. Packing is then inserted (*see Illustrations 43–45*).



19

Tympanoplasty by combined approach (posterior tympanotomy)

Posterior tympanotomy is usually recommended for chronic ear disease, even when the extent of the pathology is uncertain. The advantage of this approach is that it allows preservation or restoration of the posterior wall and bony sulcus, which will provide essential support for the new allograft tympanic membrane.

Aims

Eradication of disease

Since each part of the tympano-ossicular chain can be totally or partially replaced by preserved allogenous material, a radical attitude is certainly justified during this stage of the procedure. However, over-enthusiastic removal of tissue should be resisted.

20 & 21

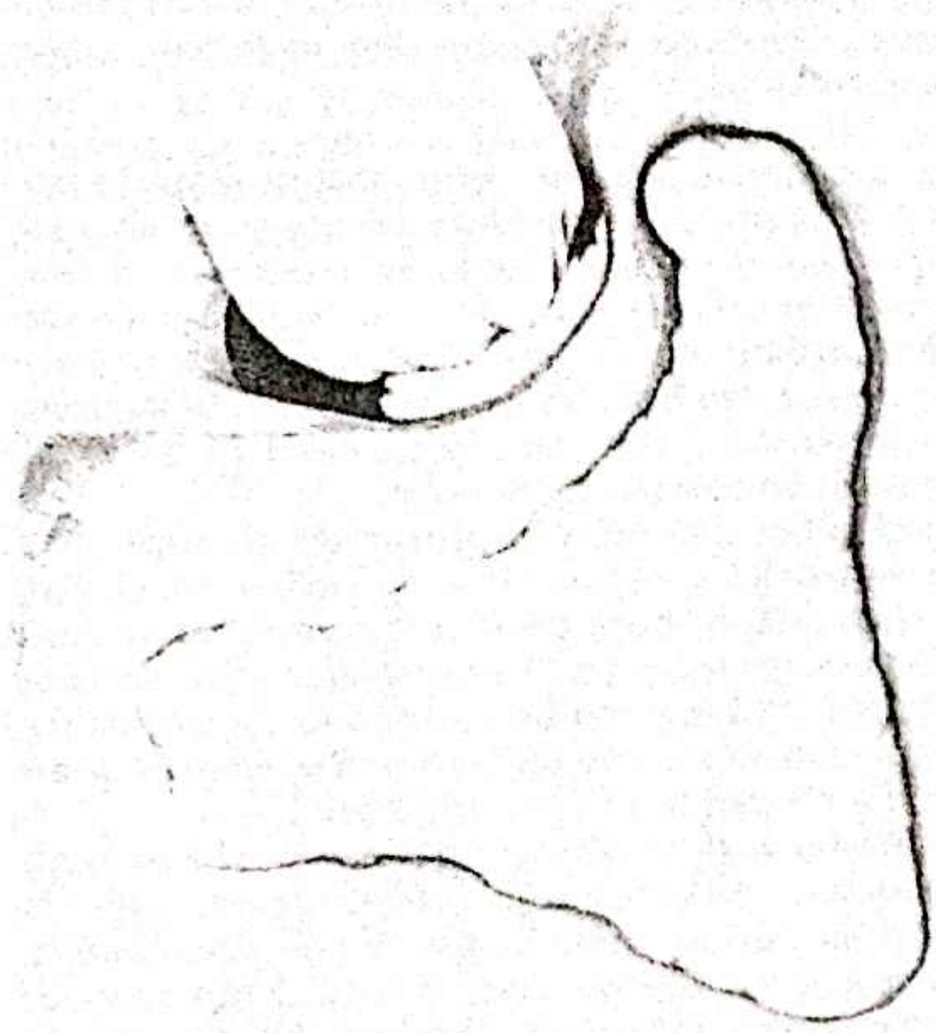
The choice of surgical approach is important. A large retroauricular combined approach, allowing complete visualization and assessment of the pathology, whatever its nature and location, is essential before any attempt is made to remove it. Skill and conscientious technique during this stage of the procedure are vitally important to success and preservation of the posterior wall is of secondary importance.

It is essential that all drum remnants, including the fibrous annulus, and any diseased tissue (e.g. cholesteatoma) are elevated laterally, together with the meatal skin, excised and removed. This is most easily done with artificial sponges and a specially designed sponge elevator.

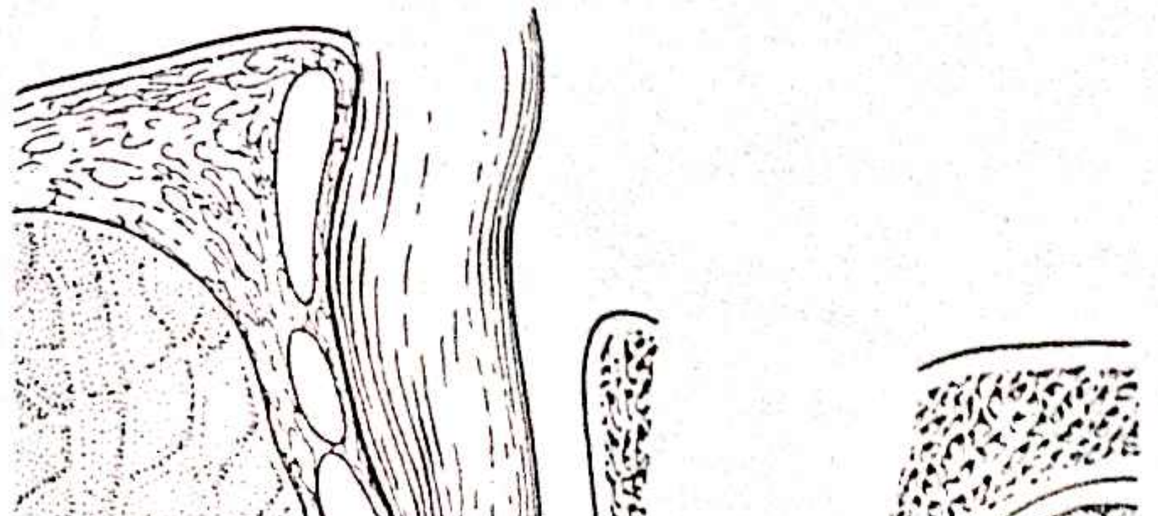
Histopathological examination of such specimens has shown that 'myringectomy' is an essential part of the procedure. This view is supported by our own comparative study, which revealed no correlation between external otoscopic appearance and histological changes on examination of the drum and annular remnants.

Unsafe ossicles, the stapes footplate being the only exception, should be completely removed, when necessary, in view of the high incidence of involvement by osteitis or other hidden pathology, such as cholesteatoma. Ossicular remnants, e.g. the head of the malleus, may have to be removed, as full visualization of the entire middle ear cleft, particularly of those areas which are easily overlooked, is essential if all disease is to be eradicated. The hypotympanum may harbour disease behind remnants of fibrous annulus, while disease in the protympanum (tympanosclerosis, cholesteatoma, epidermosis, polyps or even a simple scarred membrane) is responsible for about 10 per cent of all cases of residual tubal dysfunction. The epitympanum, and particularly its anterior segment including the so-called epitubal sinus, must also be carefully inspected. This area, which corresponds to the anterior mallear ligament and the frontal aspect of the tensor tympani tendon, can only be visualized after removal of the malleus head. It contains keratinizing epithelium in nearly half of all cases with cholesteatomatous otitis. The facial and pyramidal recesses of the retrotympanum can only be cleared of pathology once the incus or its remnants have been removed. The sinus tympani must be approached by a posterior tympanotomy.

The whole mastoid must be inspected in this way and all disease removed, paying particular attention to the tip of the mastoid.



20



21

Anatomical restoration

Once all disease has been removed from the middle ear cavity, attention is turned to anatomical restoration, including replacement of its natural closure, the tympanic membrane. The following points are important for a successful outcome:

1. Great care must be taken to ensure that all allografts are placed in their correct anatomical position. All surrounding healthy tissue should be preserved, as this ensures regrowth of the covering layer and hence revascularization of the graft. This applies particularly to the meatal skin but also to remnants of the tendons and ligaments. In contrast, all diseased or inflamed tissue must be completely removed.
2. The bed of the graft must be prepared with great care. Once the fibrous annulus of the tympanic remnants has been removed, the bony annulus is thoroughly cleaned and if necessary restored. The bony edge, which acts as the bed for the allograft fibrous annulus, should either be adapted in size to the allograft or the allograft drum should be chosen to fit the bony edge.
3. The posterior wall must always be preserved, restored, replaced or, if necessary, reconstructed. This is essential for perfect resetting of the new drum and to avoid new retraction pockets of meatal skin. In our experience, the most suitable material for this is autogenous cortical bone (AW or AWp). Allogenous posterior wall should not be used because of its later resorption.
4. The tympanic membrane or tympano-ossicular chain should only be restored with allograft material. The most frequently used patterns of replacement are summarized below:

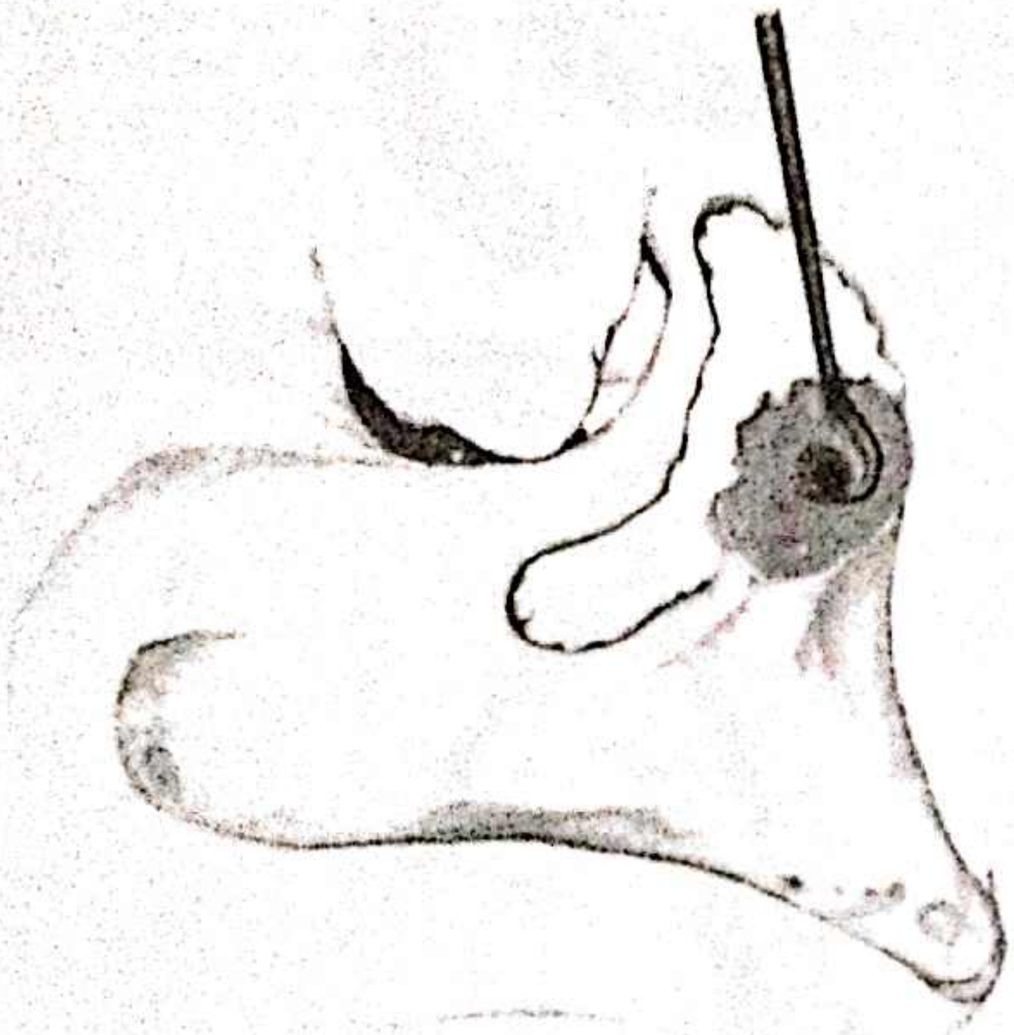
   HT+OMIS: only the drum is replaced on a normal original ossicular chain.
   HT + OM + AIr + OS: the malleus and stapes are retained and the autogenous remodelled incus is fitted between the handle of the malleus and the mobile stapes.
   HTMI + OS: the malleus and incus are replaced by a monobloc tympano-malleo-incudal graft, and only the original mobile stapes is preserved.
   HTMIS + OSp: The entire tympano-ossicular chain is replaced by a monobloc implant.

5. The tendon of the implanted tensor tympani must be put in its correct position on top of the processus cochleariformis. The stapedius tendon can be glued on its homologue from the host.
6. The meatal skin should be replaced correctly, either over the implanted meatal cuff or edge-to-edge, and glued to the bony edge.

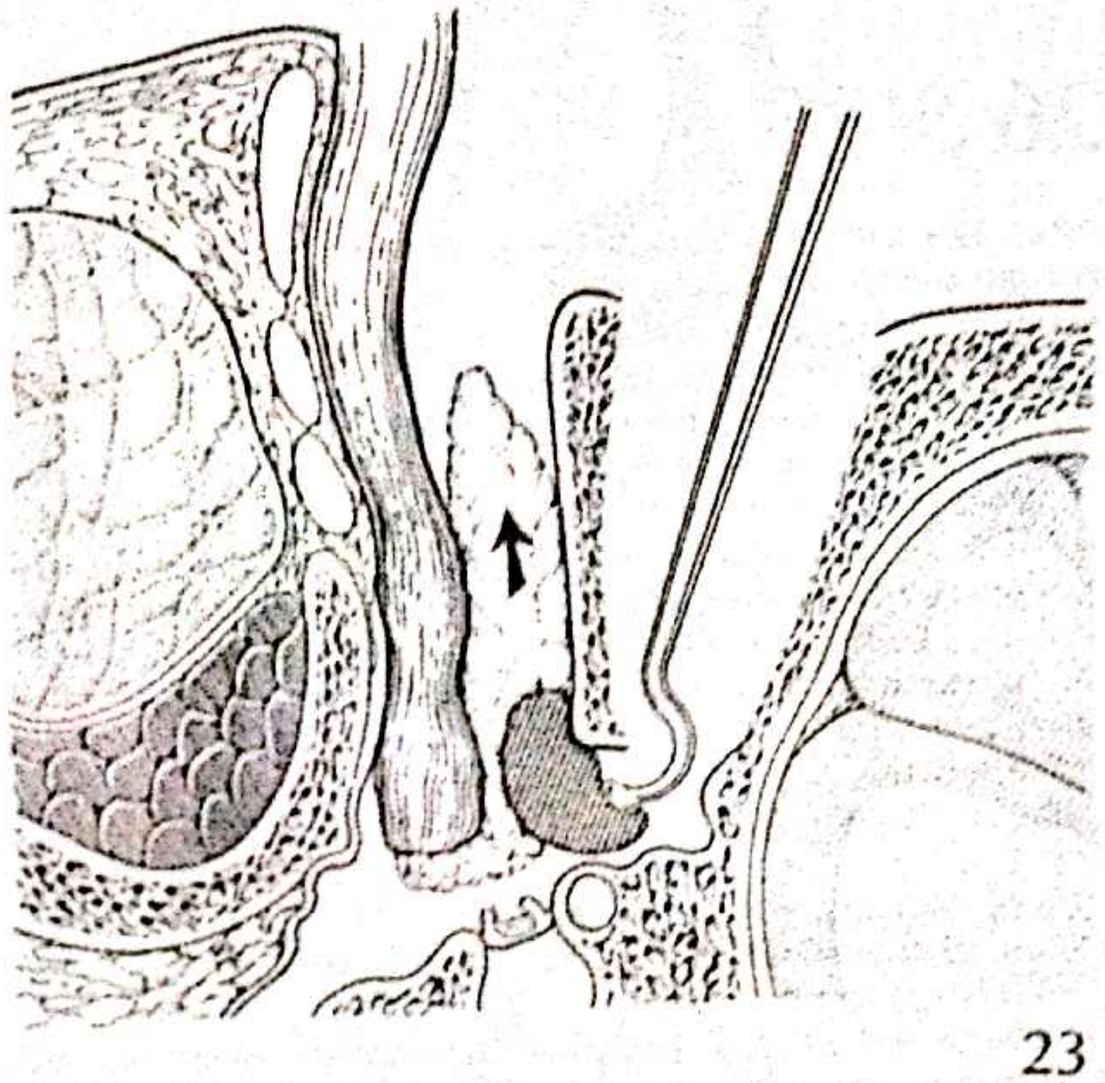
Technique

22–25

A postauricular incision is made (see *Illustration 17*) and the initial dissection proceeds as described for a posterior tympanotomy (see *Illustrations 18 and 19*). The attic, aditus, antrum and mastoid are then meticulously cleaned of all pathology. This work is continued in the middle ear, paying particular attention to the protympanum and the aperture of the Eustachian tube. As the pathology is followed, the ossicle remnants are excised and removed. Special care is taken to save a normal mobile stapes and to clean and preserve the host's tensor tympani.

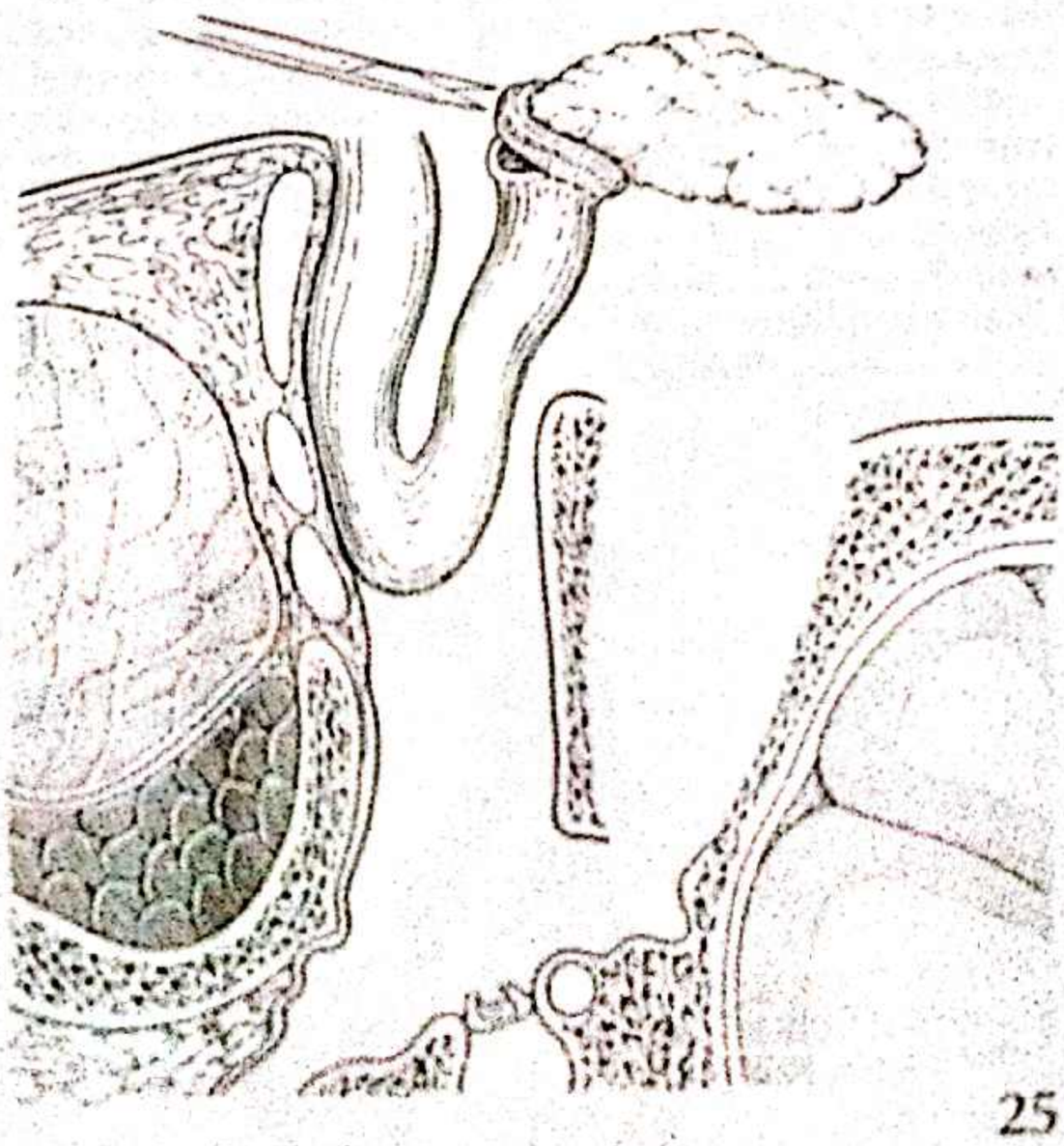


22



23

24



25

26 & 27

After assessing the size of the graft required, a suitable tympano-ossicular chain for the correct ear is chosen and washed out in saline solution. The ossicular chain is then introduced into the middle ear either by the transmeatal route or via the posterior tympanotomy, the choice depending on the existing topographical patterns.

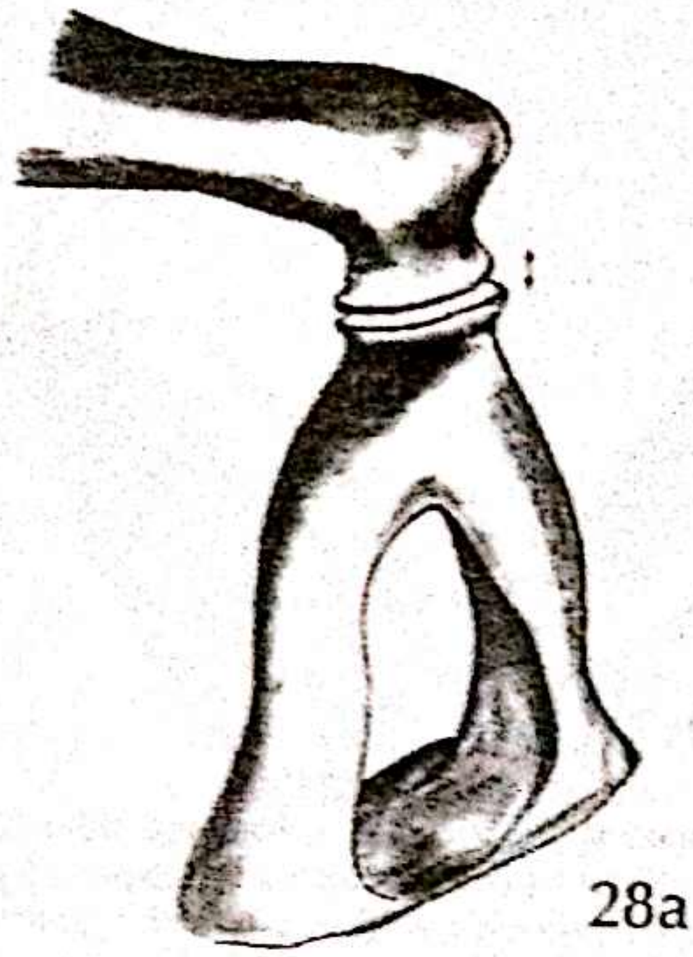
When the transmeatal route is chosen, the drum is placed gently against the anterior meatal wall and progressively pushed down towards the middle ear, the ossicles trailing behind. As soon as the incus and malleus have passed the tympanic ring, the monobloc graft falls into its correct, anatomically normal position.

When the posterior tympanotomy route is used, the whole graft (HTMIS) is gently pushed down into the cavity so that the stapes is pushed into the oval window niche. Using forceps, the drum and handle of the malleus are then gently advanced below the attic wall towards the middle ear cavity.

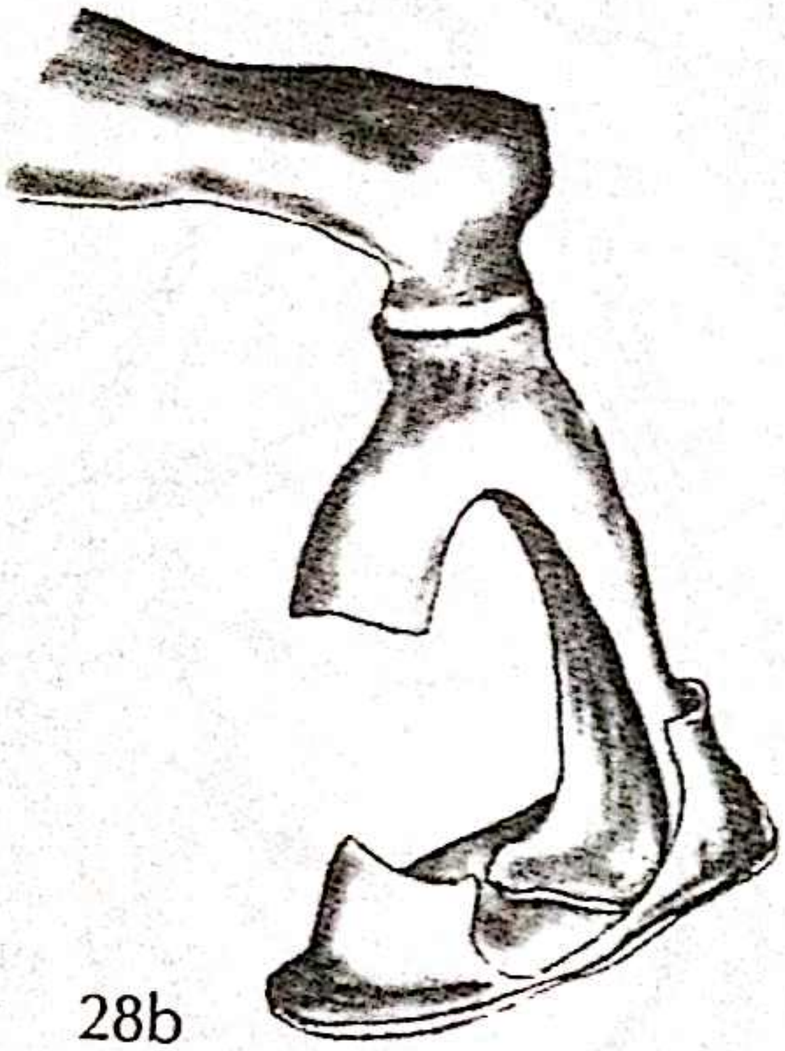
Once the tympano-ossicular graft is in its almost normal position, the following are checked and readjusted if necessary: (1) the position of the meatal skin graft against the host's bony wall; (2) correct resetting of the grafted annulus in the host's tympanic sulcus; and (3) normal mobility of the whole ossicular chain, without any contact with the bony ring or middle ear cavity, except for the stapedial footplate. The remnants of the host's tensor tympani and stapedius tendons are then placed in contact with the ends of the corresponding tendons of the graft. The same is done for the anterior and posterior ligaments of the malleus. Biological glue is used where required (see *Illustration 1*).

28a–e

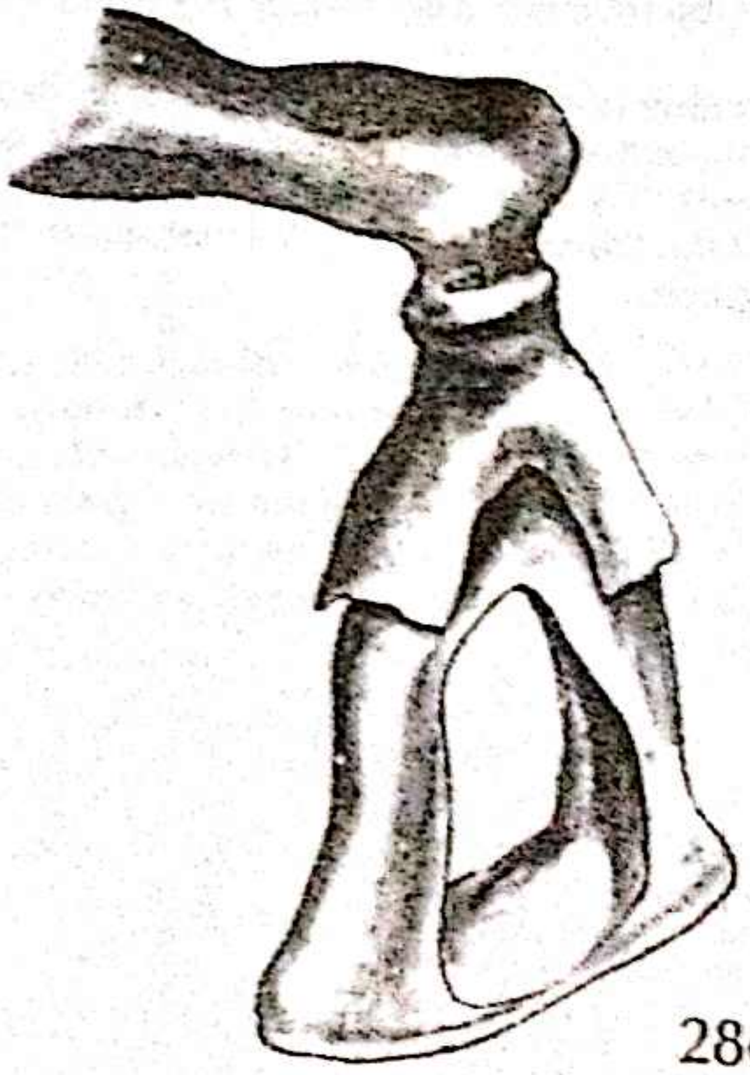
Depending on the defect, the incudo-stapedial joint may be restored by repositioning of the lenticular process on top of a normal mobile stapes (*a; see Illustration 27*), by using a partial stapes, with the anterior crus on top of a normal mobile footplate without superstructure (*b*), or the head of an allograft stapes on top of the original one (*c*); or by implanting an alloplastic or autogenic modelled ossicle (*d*). In some exceptional cases, when the footplate has either been accidentally removed or is non-existent, the normally attached stapes allograft may be placed into the oval window (*e*). The cuff and ossicles are then glued to the bony wall of the host (*see Illustration 1*).



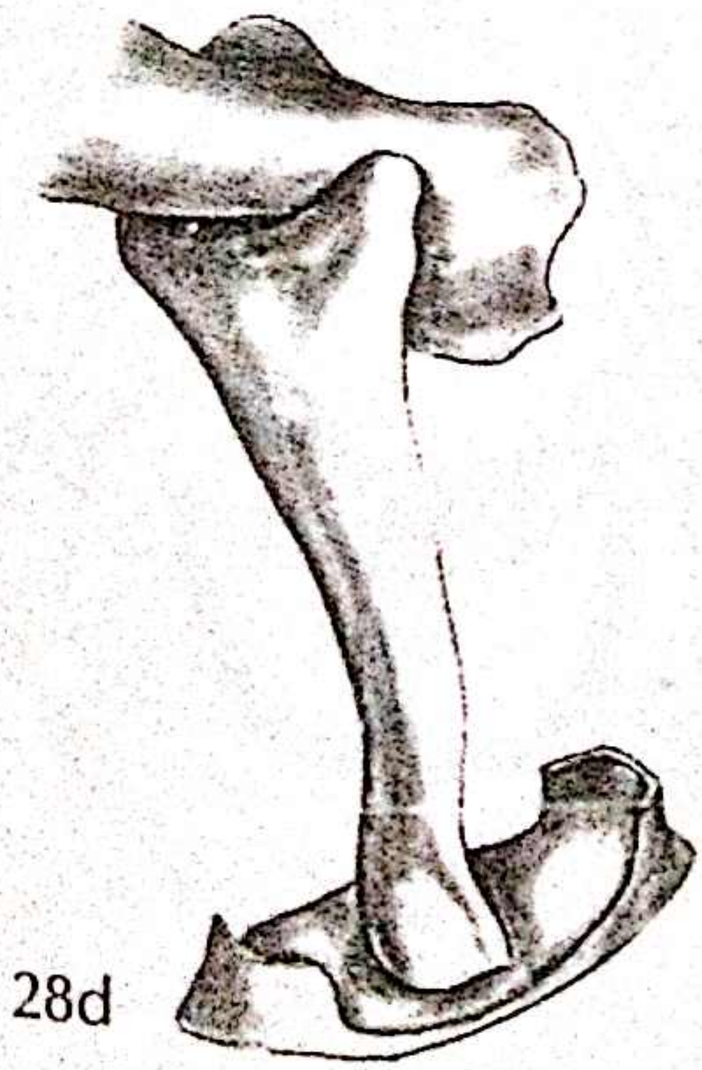
28a



28b



28c



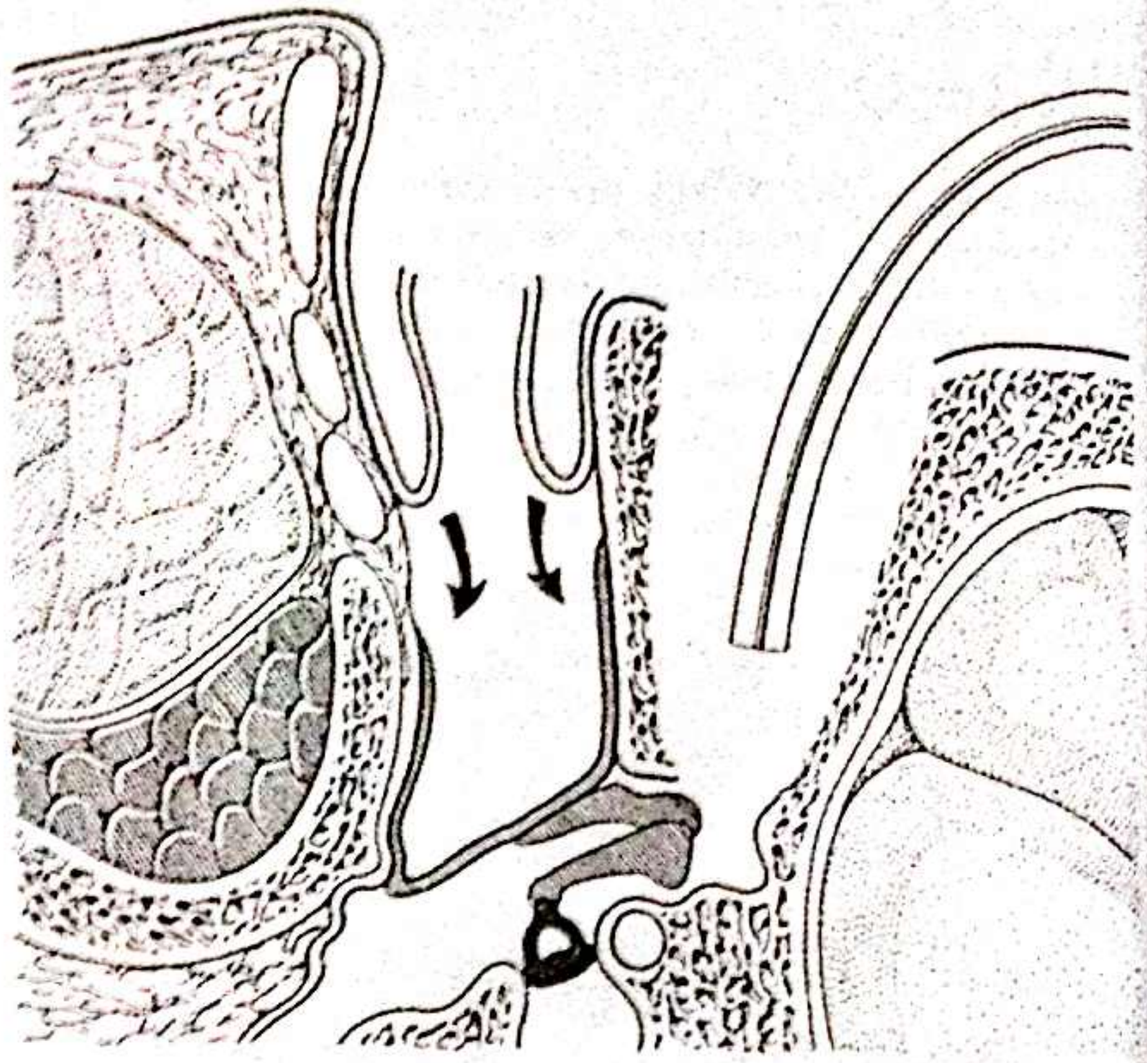
28d

28e

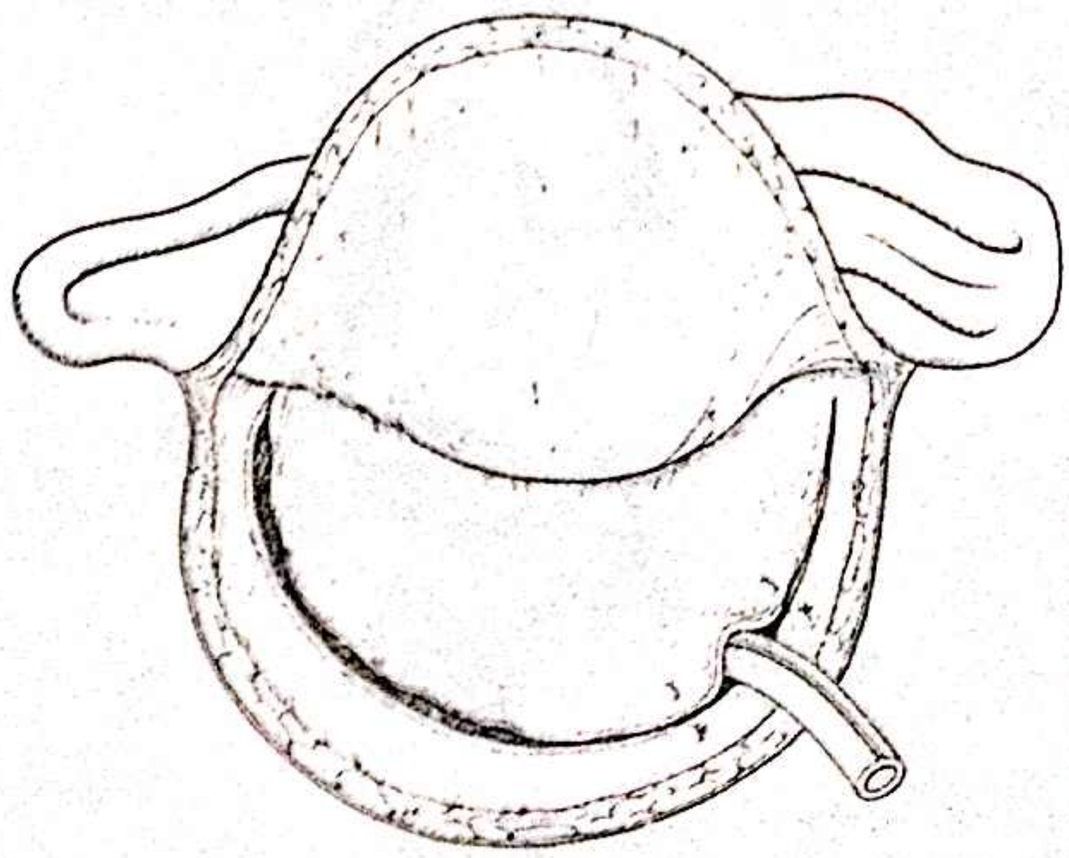
29 & 30

Before replacing the auricle, a drainage tube is put in the mastoid in order to prevent any increase in air pressure in the middle ear which could displace the drum graft. The tip of the drainage tube is placed in the lower part of the mastoid cavity, well away from the implanted ossicular chain, and the tube is brought out at the upper end of the incision.

After packing the meatus, the postauricular flap is again elevated to allow a final inspection, and if necessary readjustment (via the posterior tympanotomy) of the position of the ossicular chain, and especially of the stapes reconstruction.



29



30

Closure

The cavity is closed by suturing the periosteum and skin separately with 3/0 nylon.

Tympanoplasty with restoration of the posterior meatal wall

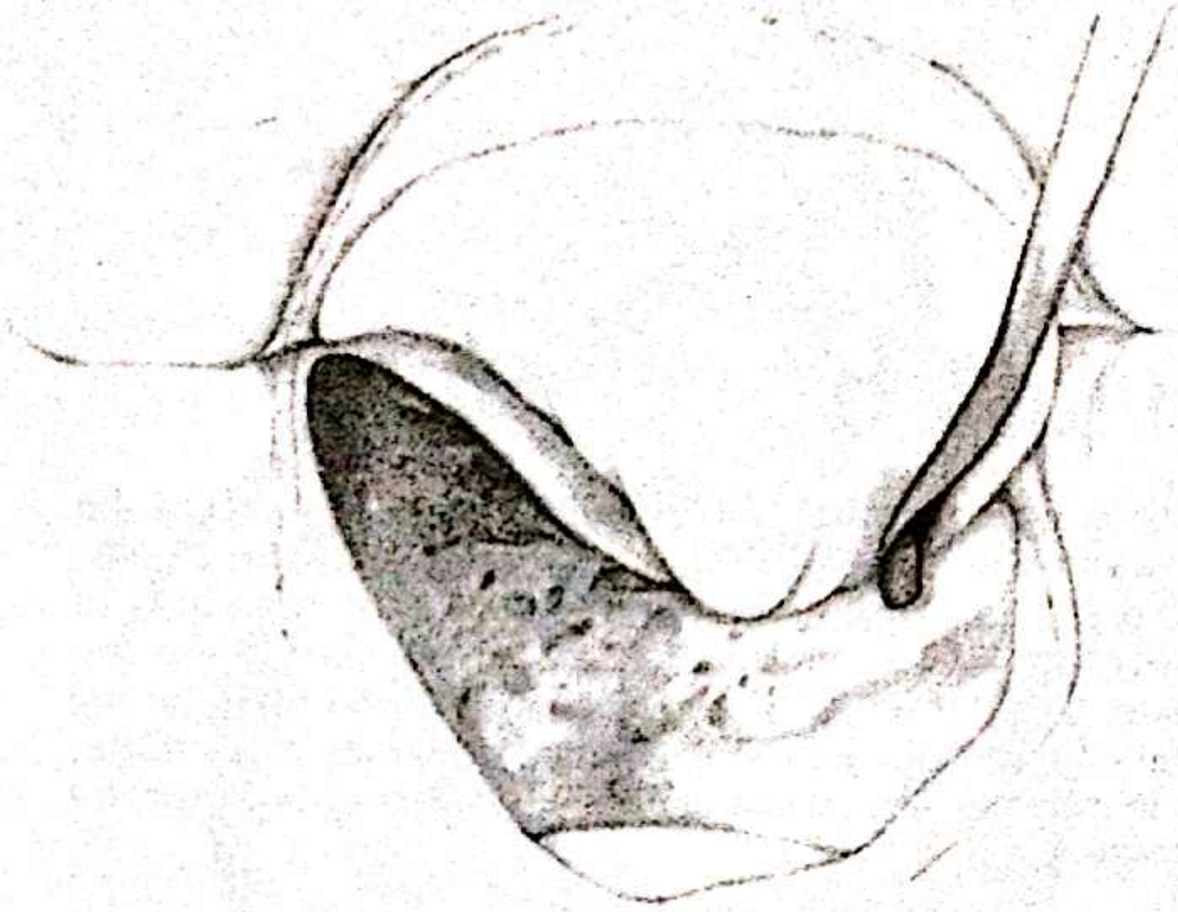
Tympanoplasty with restoration of the posterior meatal wall, using modelled autogenous bone from the host's skull, is useful in cases of congenital malformations when it has been impossible to fashion a meatus with a posterior bony wall, in cases of old radical cavities, or after previous fenestration surgery. Closure of the cavity then allows stapedectomy to be performed at a later stage, using the long process of the implanted incus.

The incision

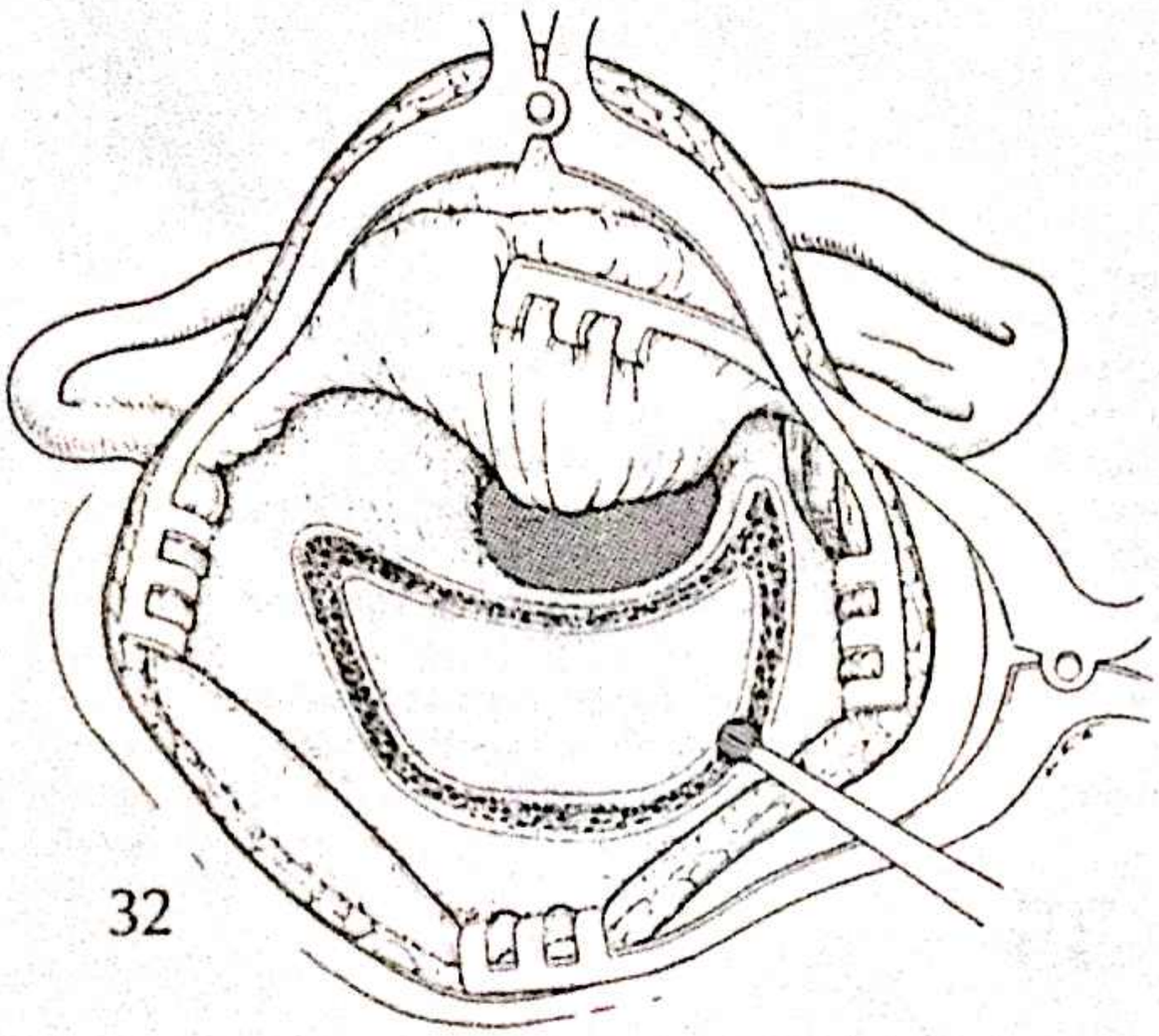
31

A retroauricular surgical incision is made 1.5 cm behind the posterior wall of the mastoid cavity.

The skin is then carefully elevated. As soon as the posterior edges of the cavity are identified, the squamous epithelium of the whole cavity is gently elevated from behind towards the anterior wall. The mastoid cavity, the external semicircular canal, the facial recess, the whole attic, the oval window and the promontory are successively freed of skin.



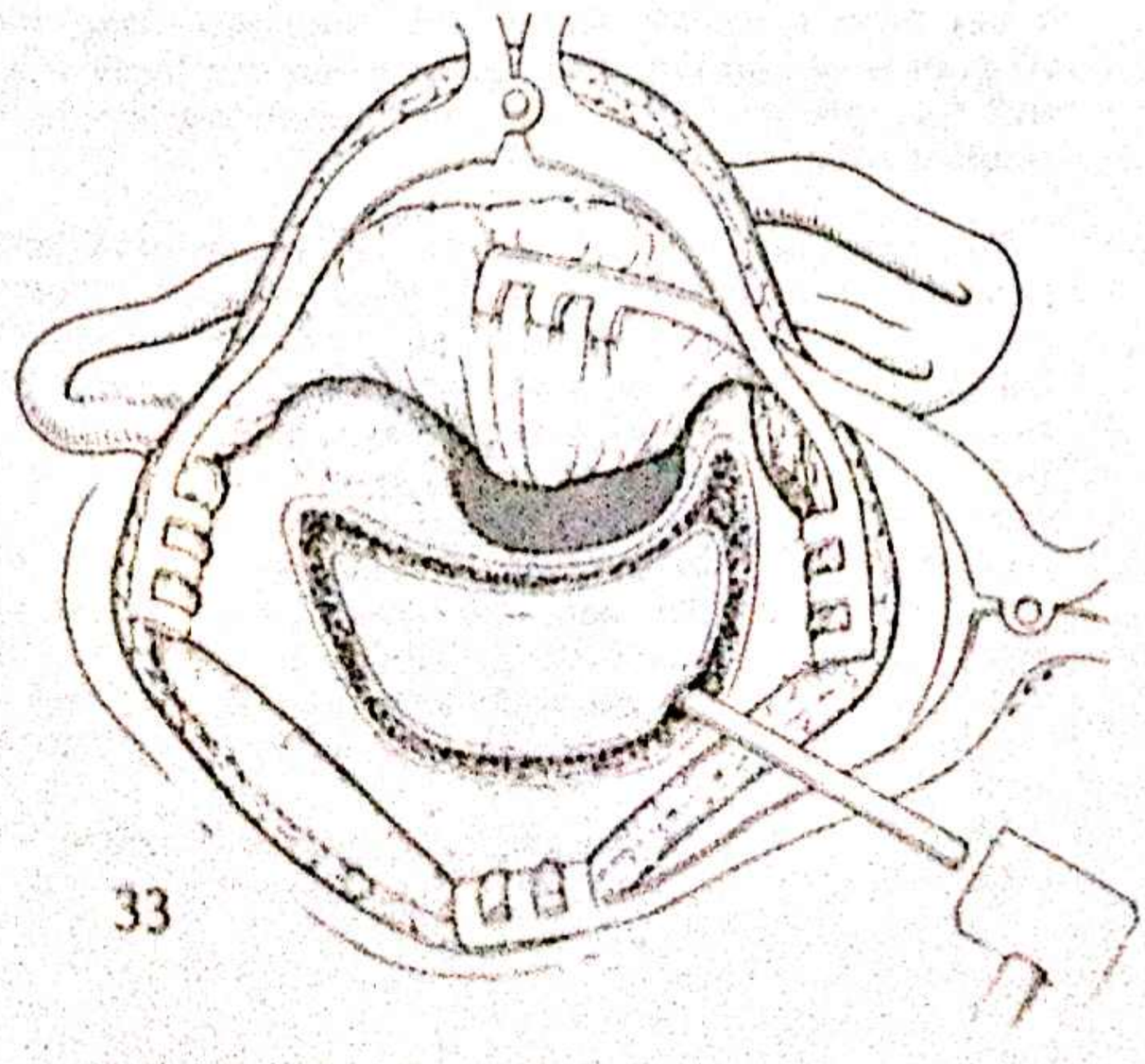
31



32

32

After the radical cavity has been cleaned, the oval window, round window and tendon of the tensor tympani are checked. The dimensions of the gap to be filled by the new posterior wall are estimated, and the outline of the required area of bone is drilled out with a cutting burr either behind or above the mastoid cavity.



33

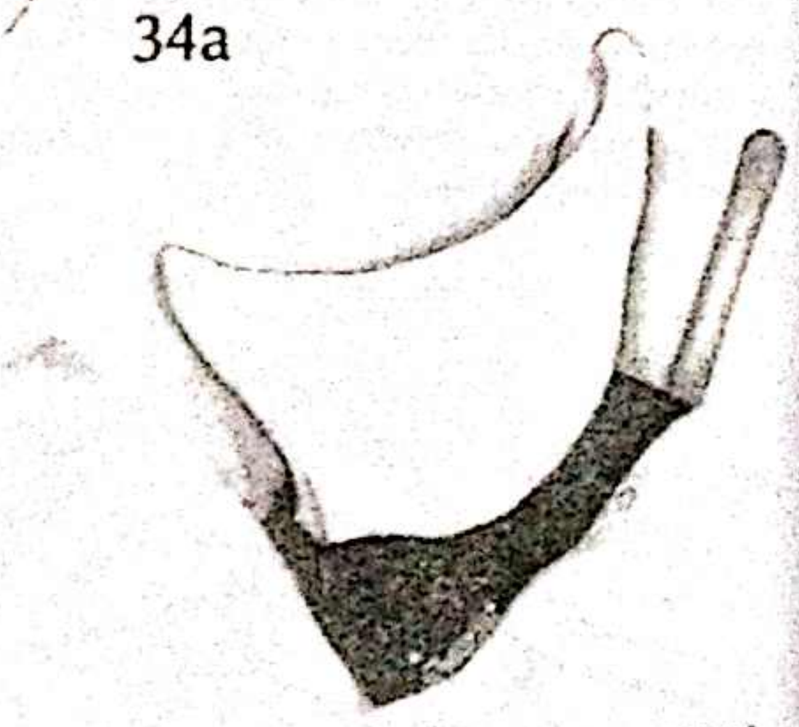
33

Using gouges and a hammer, and guided by the drilled outline, the surgeon removes the required piece of bone from the external table of the squamous bone. The natural curvature of this retromastoid area is useful in that it gives the bone graft the curvature needed for restoring the posterior meatal and attic walls.

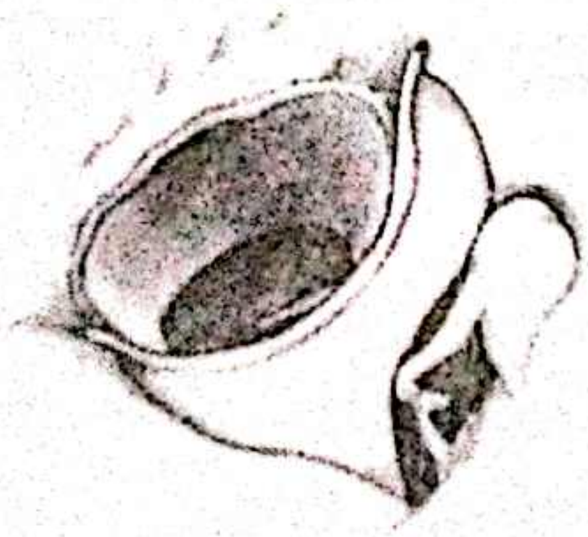
34a & b

Using a cutting drill, the bone is then sculptured to the correct size for restoration of the posterior and attic walls, and placed in saline solution. Follow-up of more than 20 years has shown that autogenous fresh bone gives the best long-term results. It is therefore preferred to any other material, such as preserved allografts or cartilage, the more so since it can be easily handled suring a second stage.

34a



34b



35

35

The chosen tympano-ossicular homograft is now introduced and positioned with the same care and attention as described in the posterior tympanotomy technique. Once it has been correctly placed, the prepared bony wall allograft is slotted into the gap between the facial ridge and the anterior meatal wall, thus restoring the bony external auditory canal.

The squamous epithelium and skin which have been elevated during the first stage are then replaced on top of the allograft. Excess skin is trimmed to obtain a complete lining for all of the new auditory canal. It is not necessary to cover the implanted tympanic membrane completely but, in order to achieve success, it is essential to have a complete covering of the new posterior wall. Points of fixation of the new posterior wall to the edges of the anterior wall above and the facial ridge below are reinforced by a cement of bone dust mixed with fibrinogen glue. The mastoid periosteal flap obtained by the initial incision may also be used to reinforce the new wall.

Packing is then put in place as described below (see *Illustrations* 43–45) and the wound is sutured.

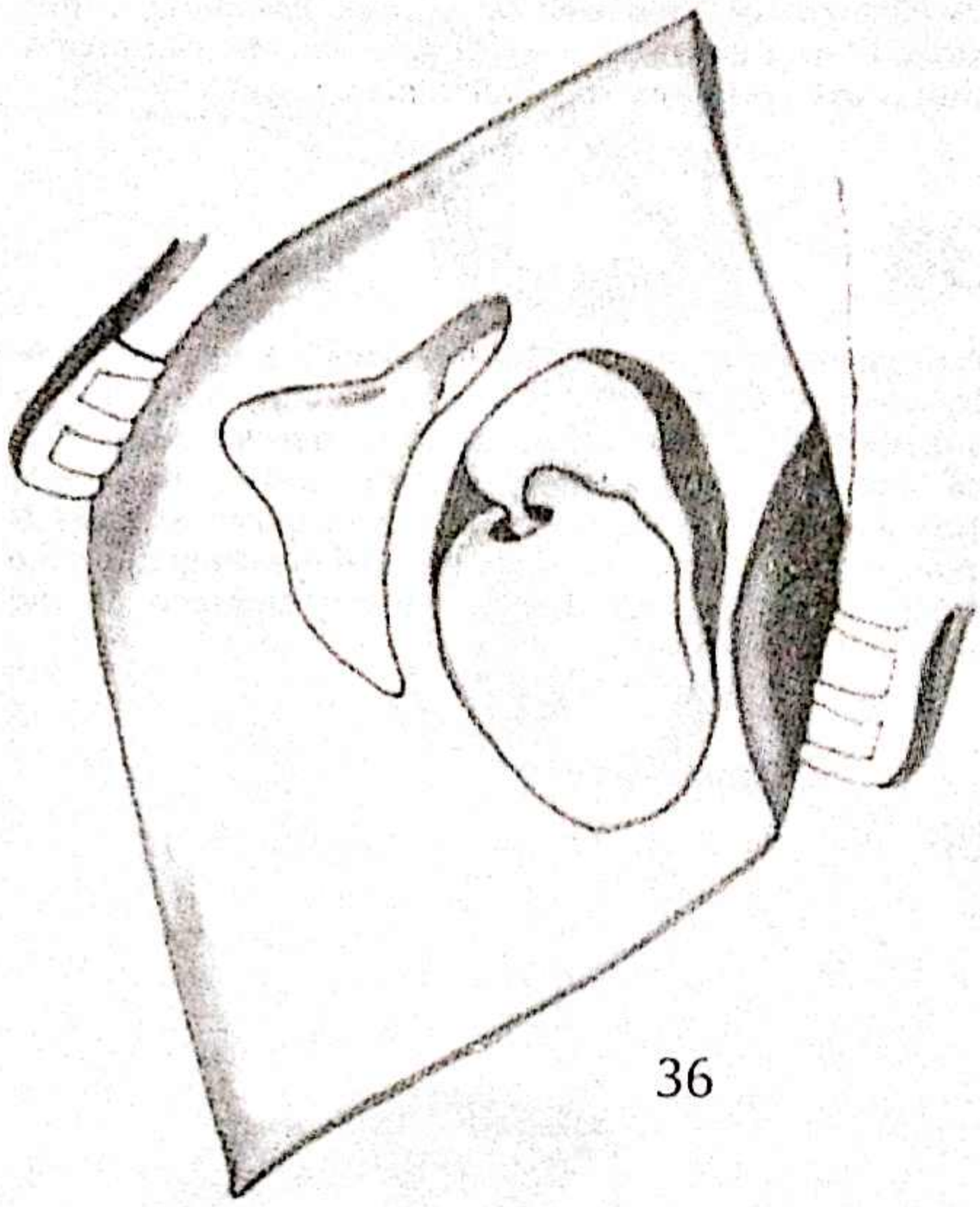
Treatment of congenital atresia

The use of tympano-meatal allografts in congenital atresia has led to unexpected and excellent results. Here, of course, the tympanic membrane has to be especially prepared, keeping the meatal cuff as long as possible.

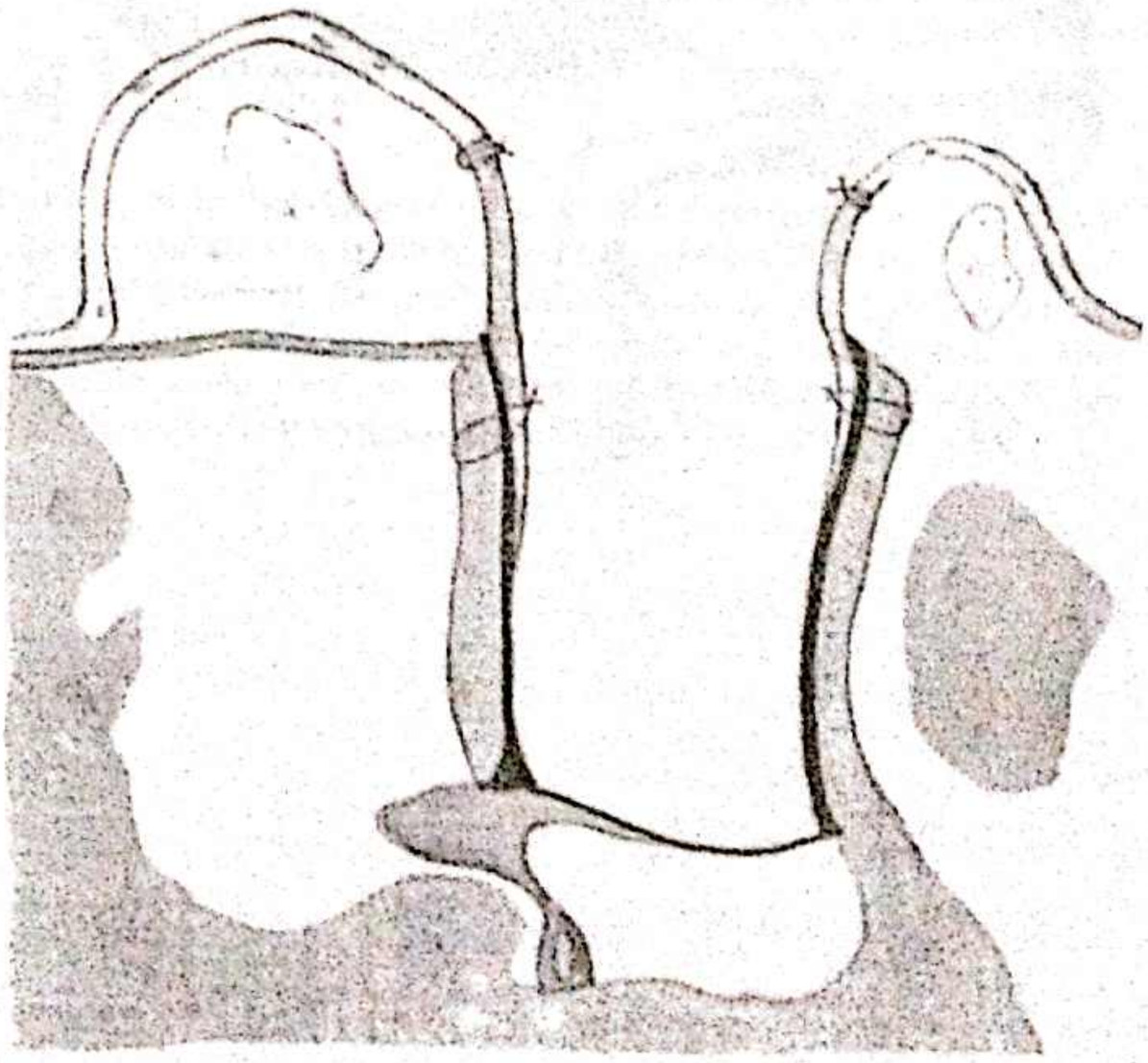
36 & 37

The technique is similar to that described earlier, but requires some modification. A retroauricular approach is again used, but with a more posterior and vertical incision of the skin. In order to create a posterior wall, which is indispensable for support of the allograft, a double approach to the atretic middle ear cleft is required: one posterior, towards the postero-superior angle of the mastoid, and one straight down towards the tympanic cavity.

The original ossicles, even when dysmorphic, are generally conserved as far as they are functional. The tympano-meatal graft is then put in place and sutured to the skin of the auricles.



36



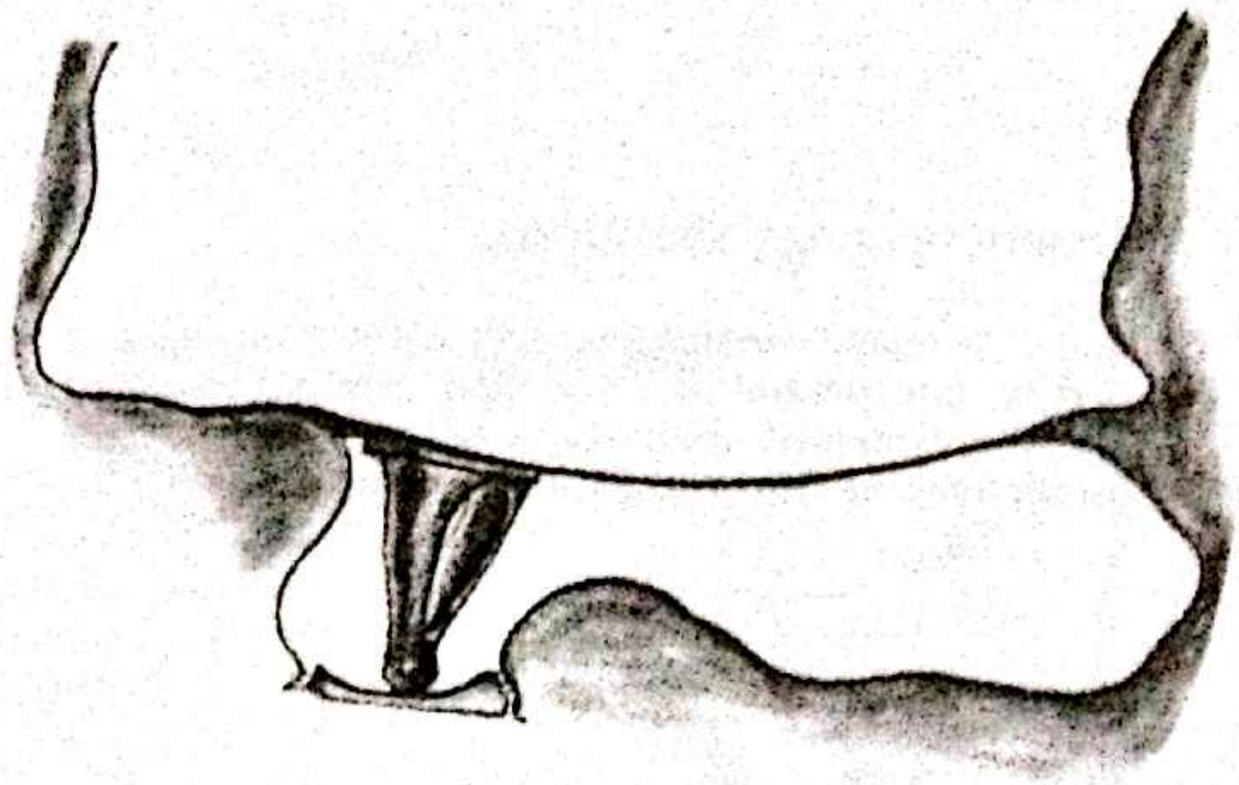
37

Ossicular implants

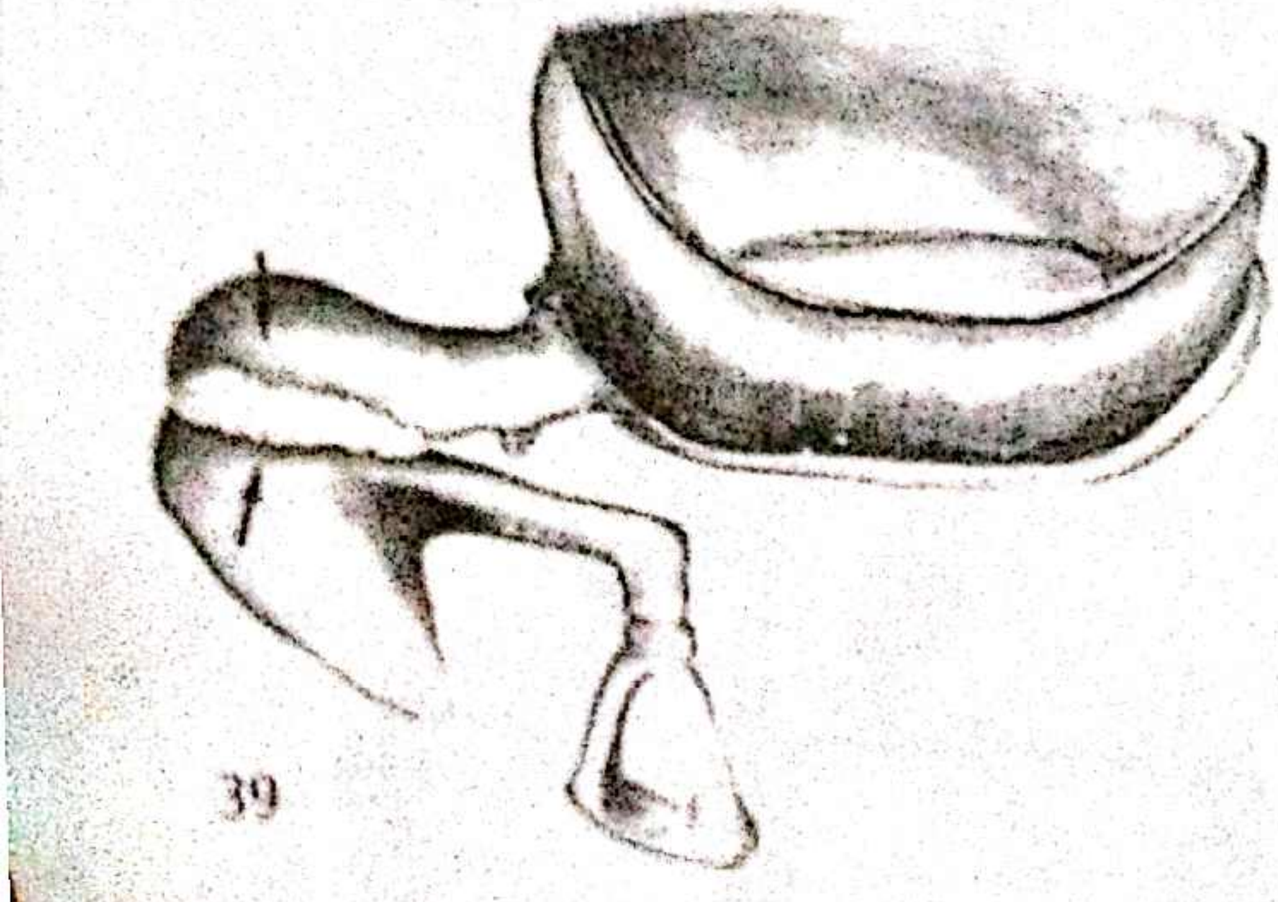
Ossicles can be used with or without modelling, either alone or as a group of articulating elements. Fibrinogen glue is used routinely for such implants.

38

A single ossicle may be used to replace a defective ossicle by positioning it in the correct anatomical site, or as a substitute prosthesis. However, this requires free mobility of the host's ossicular remnants and a favourable topography. An example is shown in which a stapes is placed upside down, with the head of the allograft on the host's footplate and the tympanic membrane on the allogeneic footplate.



38



39

39

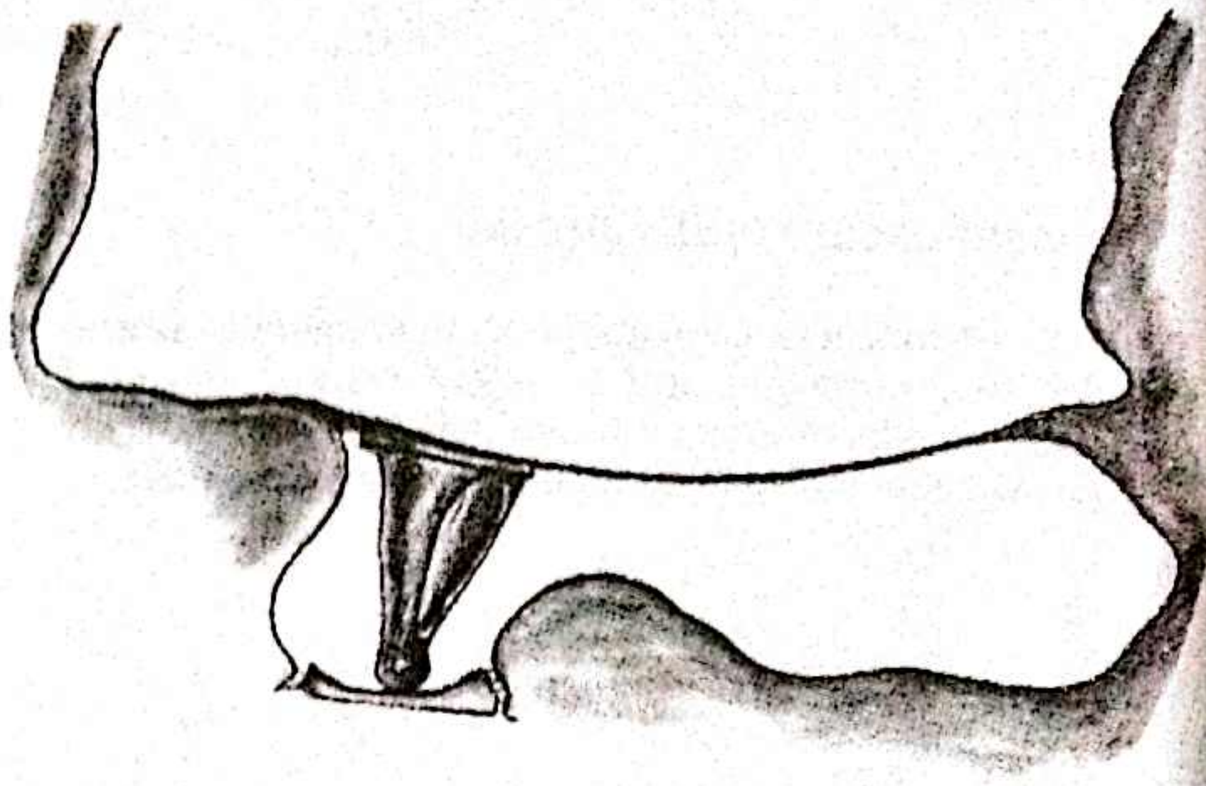
An articulating unit, for example a tympano-mallear graft, can also be used. This technique is particularly recommended when the malleus is defective but the incus and stapes are normal, as after a fracture or after previous surgery.

Ossicular implants

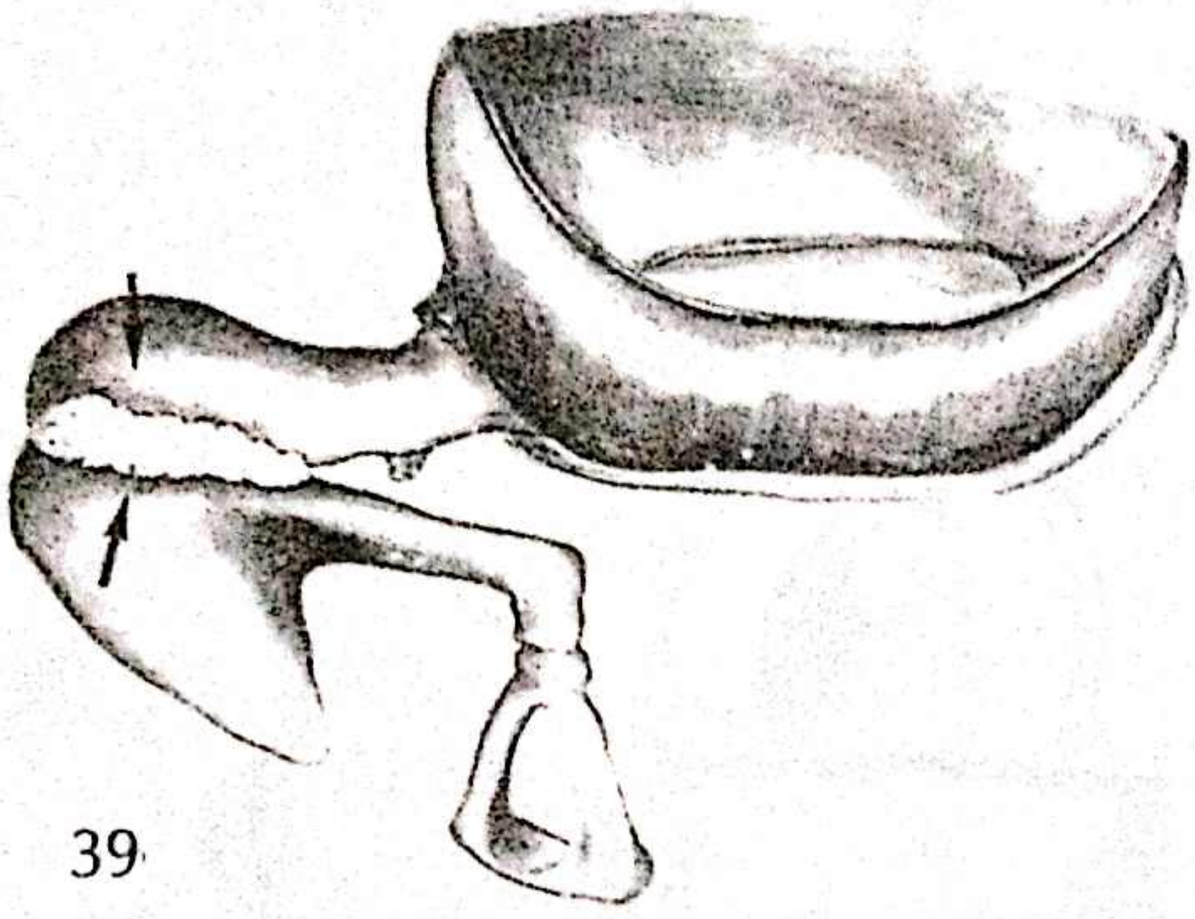
Ossicles can be used with or without modelling, either alone or as a group of articulating elements. Fibrinogen glue is used routinely for such implants.

38

A single ossicle may be used to replace a defective ossicle by positioning it in the correct anatomical site, or as a substitute prosthesis. However, this requires free mobility of the host's ossicular remnants and a favourable topography. An example is shown in which a stapes is placed upside down, with the head of the allograft on the host's footplate and the tympanic membrane on the allogenous footplate.



38



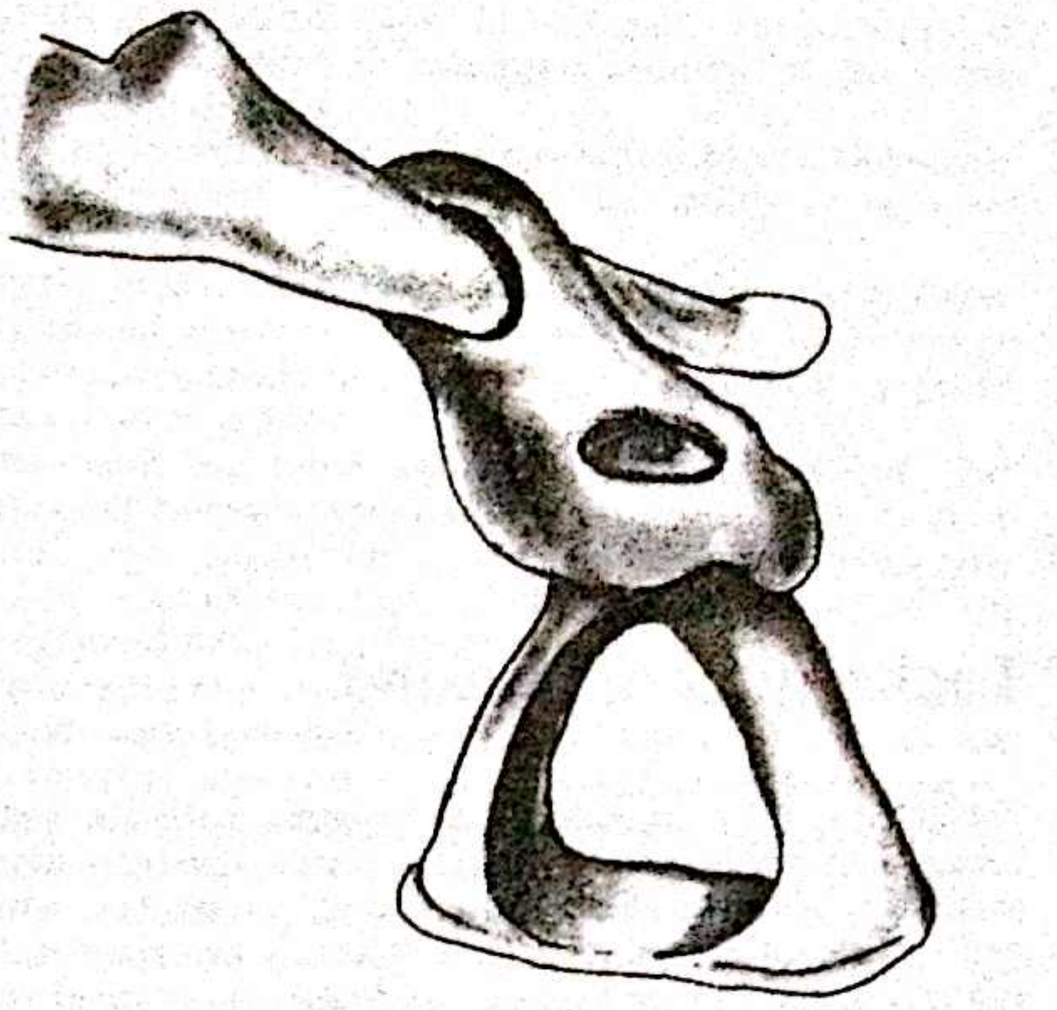
39

39

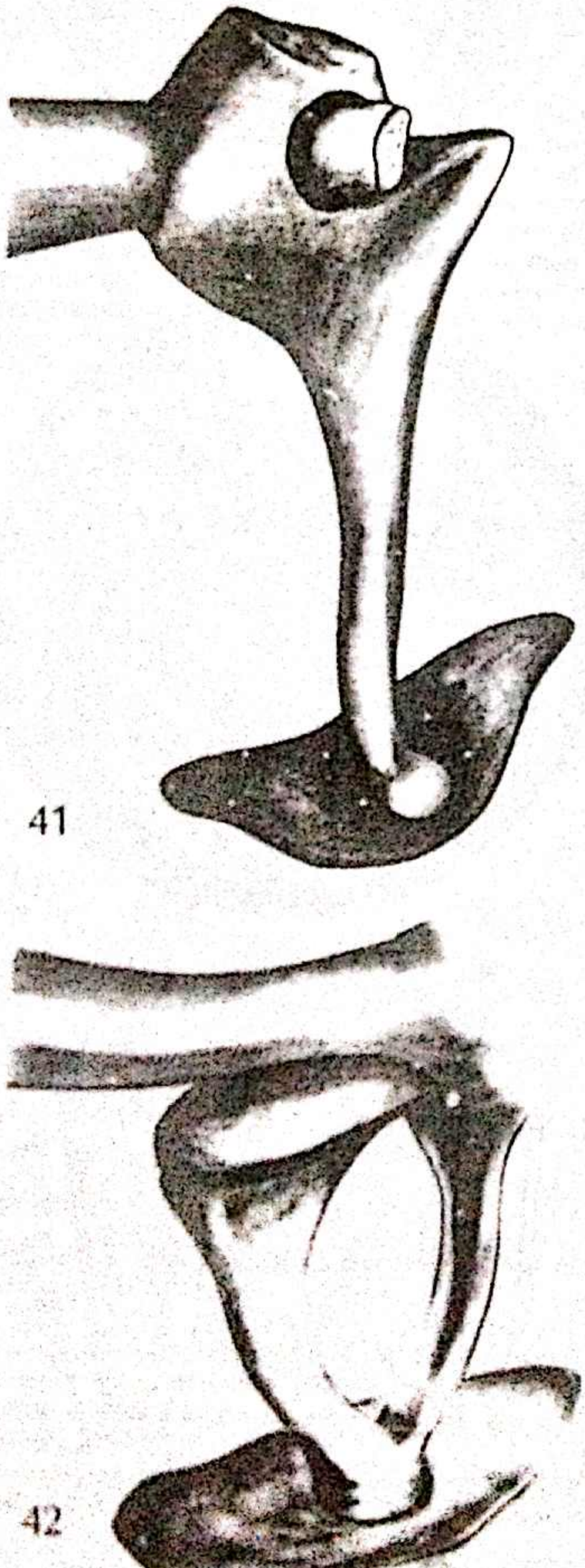
An articulating unit, for example a tympano-mallear graft, can also be used. This technique is particularly recommended when the malleus is defective but the incus and stapes are normal, as after a fracture or after previous surgery.

40

Modelled ossicle grafts, with holes or mortices to provide good fixation, also give good results. One of the most useful techniques for this type of ossiculoplasty consists of fitting the host's incus remnant between the handle of the malleus and a mobile stapes.



40

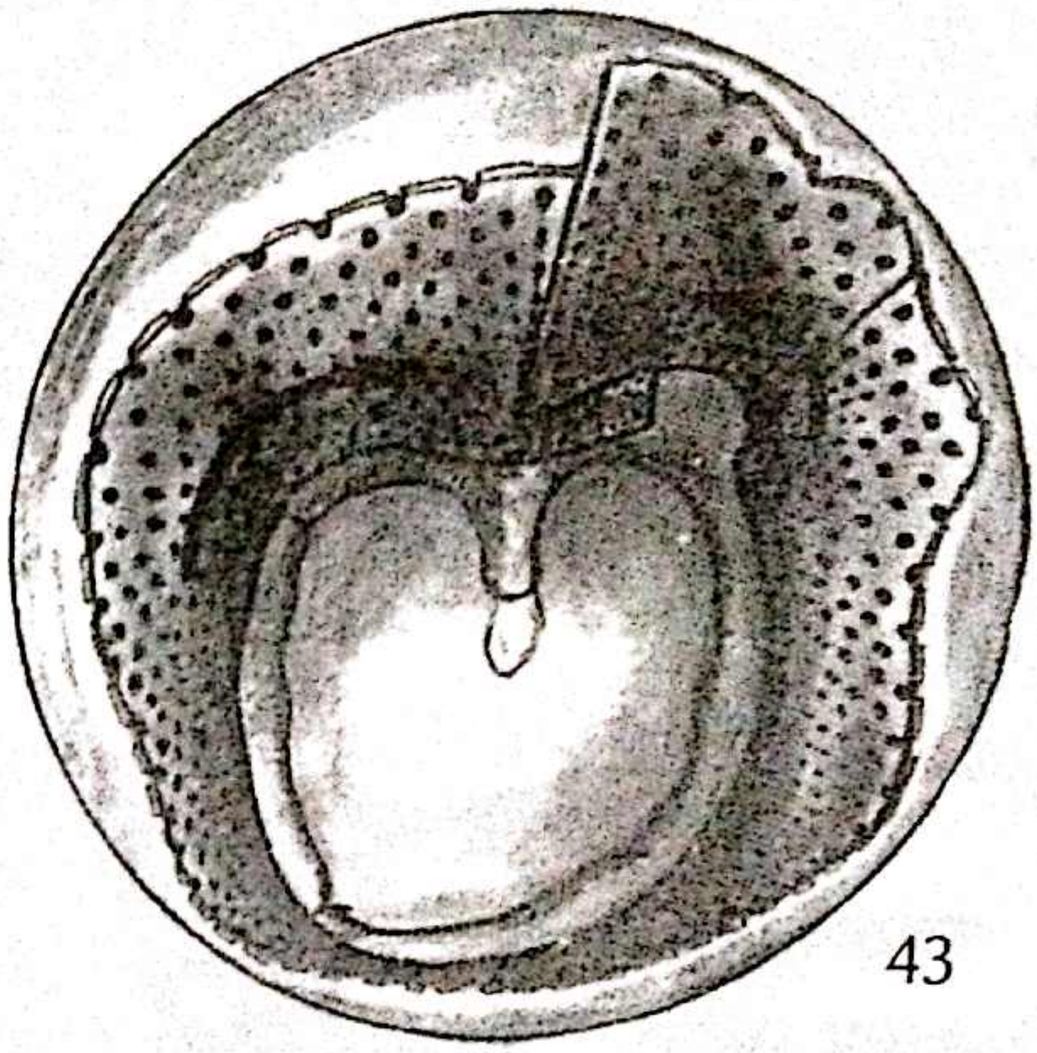


41

42

41 & 42

When only the superstructure of the stapes is absent, very good results can be achieved by using either modelled or partial ossicular allografts. The choice of graft depends on the anatomical pecularities of each case and includes the handle of the malleus or a remodelled malleus allograft, or an upside-down stapes (*see Illustration 38*)



43

Techniques of packing

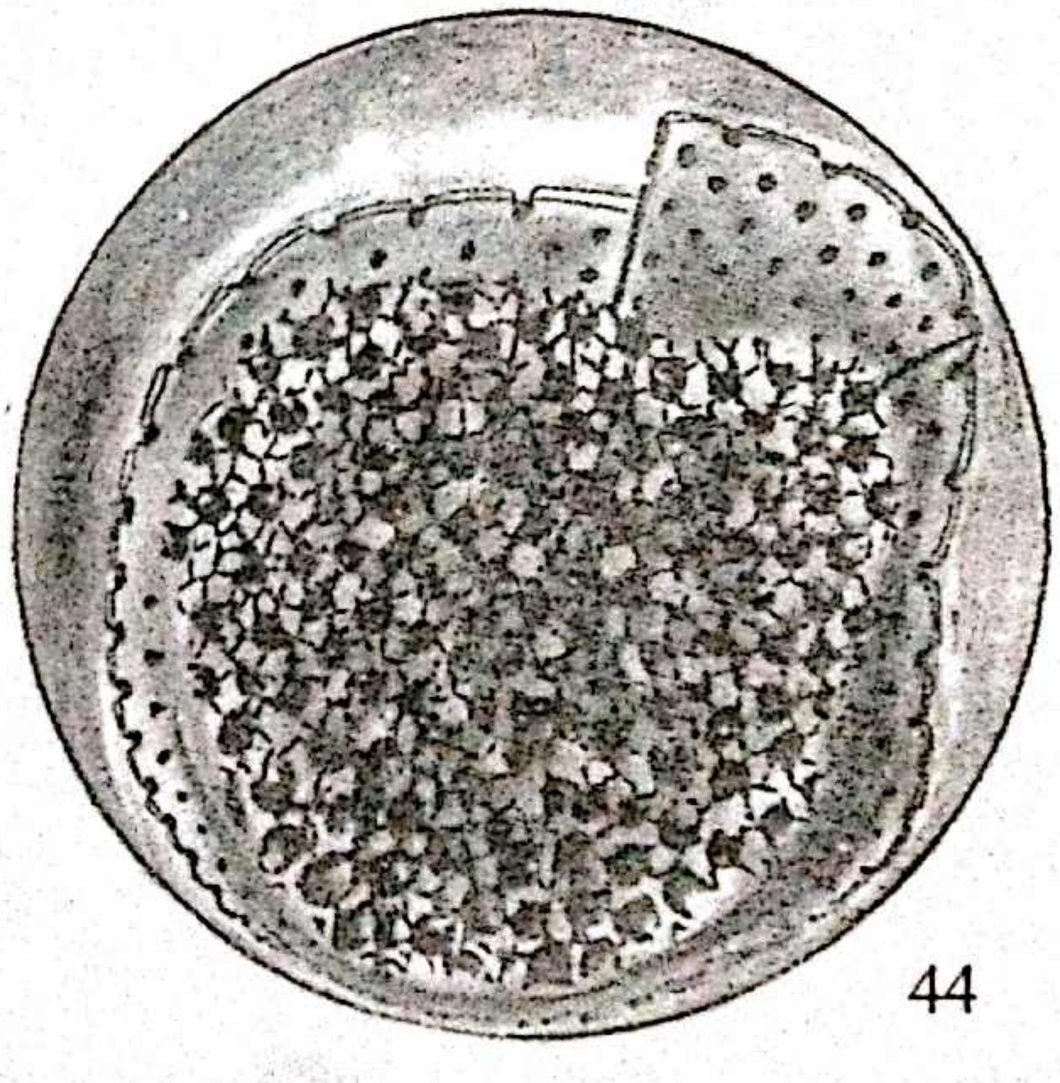
Packing must be considered as an important part of the surgery. In addition to its retaining action, correct packing maintains good aeration and prevents maceration, while preserving sufficient humidity – all factors which assist the rapid growth of epithelium and the success of the operation. Artificial sponges achieve these aims.

43, 44 & 45

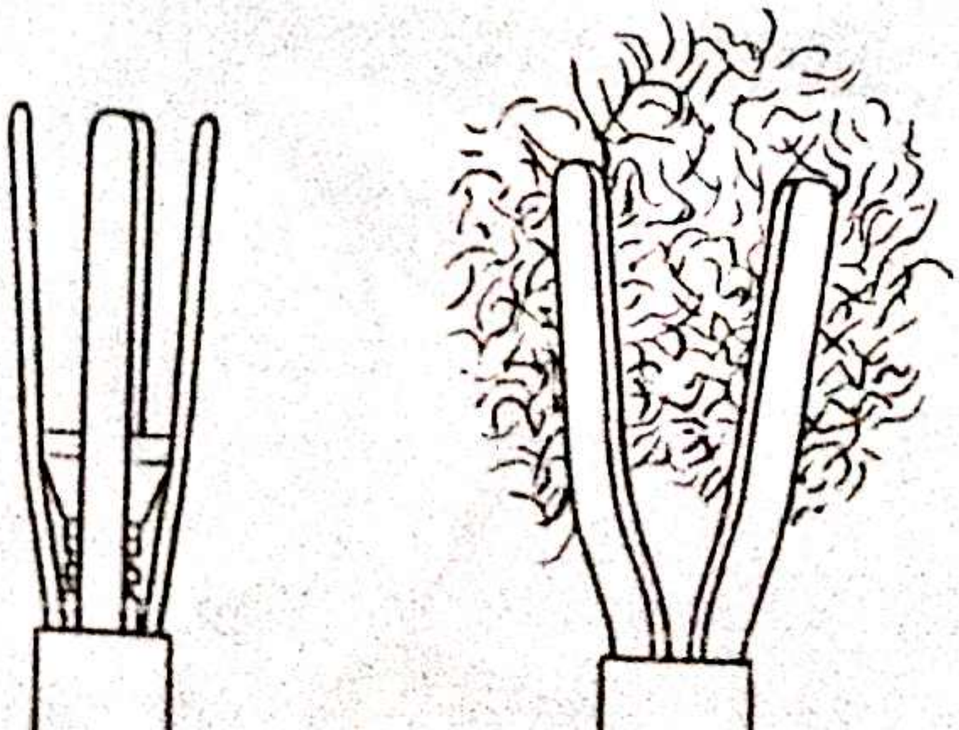
Replaced epithelium must be protected, as there is a risk that, when removing the sponges, the skin will be torn off. This is best done by inserting a piece of perforated silastic, rolled up like cigarette paper, into the auditory canal and pushing it gently against the wall covered by the new, stretched epithelium.

Fibrinogen glue is used less often here because of the risk of infection and thus of granulation.

Three or four artificial sponges, soaked in an antibiotic/steroid ointment, are then gently introduced into the canal, using a specially designed sponge forceps.



44



Postoperative care

The drain is removed on the fourth postoperative day after gentle suction through the drainage tube. The artificial sponges are removed 6 days after surgery. The new implanted drum generally appears very clear, like a normal one. The piece of silastic is then gently elevated and removed. Any minor corrections to the stretched epithelium can be made at this time. The position of the drum is checked. From that day on, only antibiotic ointment is put in the ear and general antibiotic cover is advised. Cleaning of the ear is carried out 3 or 4 weeks later.

Results

Long-term results have been excellent. After a follow-up of more than 20 years, two of the three goals of surgery have been achieved in almost all cases (healing of the middle ear in 92 per cent and anatomical restoration in 96 per cent of cases). Functional results have also been good, but since they depend on many factors other than the surgical procedure, function may still be impaired even after successful removal of disease and anatomical restoration of the middle ear.

Causes of failure

In a total of more than 4000 allograft operations, 200 cases have been studied for causes of failure.

Table 1. Causes of failure (n = 200)

	Incomplete healing (%)	*Failure to restore anatomy* (%)	*Poor functional result* (%)
Technical faults	15	22	25
Residual pathology	37	29	36
Recurrent pathology	41	31	28
Postoperative packing problems	6	14	9
Others	1	4	2

Technical faults

Technical faults account for 15–25 per cent of the poor results of surgery (see Table 1).

1. Lateral displacement may occur if the fibrous annulus of the graft has not been placed correctly on the original or restored bony annulus and on top of the manubrium.
2. Postoperative ankylosis of the implanted ossicles with the wall of the middle ear can be corrected relatively easily at a second stage. (It may even be considered beneficial in that it enhances viability of the new implanted ossicles.)
3. Defective restoration or implantation of the posterior wall frequently leads to the formation of a new retraction pocket.
4. Perforations or small dehiscences in the implanted tympanic membrane inevitably lead to early post-operative perforation. This is generally due to poor selection of grafts.
5. Remnants of dead squamous epithelium on the allograft tympanic membrane, and particularly its skin cuff, invariably result in a weak and granulomatous drum. Careful curettage of the external layer of the implanted drum usually solves this problem.
6. Poor replacement of the allograft skin cuff may create a dead space between the wall and the cuff or leave an uncovered area of bone in the external auditory canal, both of which increase the risk of later complications. Iatrogenic epithelial pearls may also result from incorrect skin replacement.
7. Dislocation of an implanted ossicle, usually due to careless manipulation during surgery, is irreparable and will preclude a return to normal function.

Residual pathology

Residual disease accounts for approximately one-third of the complications and poor results of surgery (see Table 1). Mucosal pathology may prove impossible to eradicate, while residual cholesteatoma is usually due to failure to remove the cholesteatoma matrix. Residual tubal dysfunction is rare if the protympanum has been cleaned thoroughly. (The nasopharynx should have been cleaned preoperatively.) Stapes ankylosis due to otosclerosis, tympanosclerosis or post-infective arthrosis may cause irreversible ossification and lead to obliteration of the oval window. In such patients a hearing aid is usually preferred; later stapedectomy has been performed in only 5 per cent of these cases.

Recurrent pathology

This also accounts for approximately one-third of poor results (see Table 1).

1. Cholesteatoma may re-form in a new retraction pocket or recur as an epithelial pearl on the tympanic membrane.
2. Re-infection of a surgically cured ear is, of course, possible and may be responsible for late perforation. It is treated, as usual, by paracentesis or trans-tympanic drainage.
3. Recurrent tympanosclerosis is a late complication and is not amenable to treatment.
4. Diseased surrounding skin may induce a similar pathological change in the implant (e.g. leading to a granulomatous drum).
5. Recurrent osteitis, lysis or necrosis of the ossicles is rare in dry uninfected ears, but may occur in ears which become infected postoperatively. In this case, it usually affects the remaining original ossicles, particularly the stapes, rather than newly implanted ossicles.

Others

Problems due to packing or postoperative care account for some 10 per cent of poor results (see Table 1). Lateral displacement of the inferior part of the external meatal skin due to bleeding under the replaced meatal skin may lead to a vicious overgrowth of epithelium and fibrous obliteration of the inferior sulcus. This is easily restored under local anaesthesia. Stenosis of the ring is usually due to premature removal of the pack or poor replacement of the external meatal skin on top of the graft. It may also occur if the fibrous annulus has not been correctly excised.

Occasionally a poor result is due to other factors, e.g. trauma or burns during surgery.

Conclusion

Despite the excellent results which have been achieved with this technique over the last 20 years, the use of allogenous transplants has not yet found widespread acceptance. This is partly due to medico-legal problems. So far, collection and transplantation of human temporal bone is legally allowed in only a few countries. However, as a result of recent EEC recommendations, every interested medical centre in the European Community should soon be able to collect such tissues. The size of the required donor pool also presents formidable problems. Only about 40 per cent of collected specimens are suitable for transplantation (the remainder being rejected because of either the type of disease reponsible for the donor's death or disease in the donor ear itself). One-fifth of these are subsequently rejected because of deterioration or contamination due to incorrect preparation or storage. This means that 100 donors (or 200 temporal bones) are needed to obtain 64 specimens suitable for transplantation. For routine work using temporal bone alone (assuming 15 cases per week) an average of 10 left and 10 right ears would be needed to allow for any abnormal tympanic membrane size, tearing of the graft, or dislocation of the ossicular chain during surgery.

Financial cost is another important factor. The running of a tympano-ossicular bank requires not only well-trained technicians and specially designed instruments but also special facilities for bacteriological examination to ensure the safety of all implantation tissue.

Unfortuntely, too many surgeons are still deterred by their own poor results. However, with proper attention to the principles and techniques outlined in this chapter (including anaesthetic technique, packing and postoperative care) these should improve dramatically and there is no doubt that the technique will become more popular in the future.

Illustrations by Daniel Slotton

Conversion of the radical mastoid cavity for obliteration or reconstruction

Jack L. Pulec MD
Pulec Ear Clinic; President, Ear International;
Clinical Professor of Otolaryngology, University of Southern California, Los Angeles, California, USA

Preoperative

Indications

The radical mastoid cavity not only produces a hearing loss but is often associated with persistent otorrhoea or recurrent accumulation of epithelial debris. A properly performed radical mastoidectomy should result in a dry trouble-free ear. Recurrent drainage occurs when the Eustachian tube has not been sealed, when mucous membrane of the middle ear and mastoid is left exposed, or when cholesteatoma or granulations have not been exteriorized and areas of the cavity are not accessible. The patient whose cavity requires frequent visits to the otologist's office for removal of debris or whose infection and otorrhoea cannot be controlled by local medical treatment may be improved by surgical correction.

Contraindications

In the absence of disturbing symptoms the presence of a mastoid cavity does not in itself indicate need for surgery. Tympanoplasty to reconstruct the tympanic membrane and ossicular chain, to seal an exposed middle ear and improve hearing is best accomplished without tampering with a dry trouble-free cavity.

Special equipment

As in all otological surgery, a Zeiss operating microscope, suction irrigators, and diamond and cutting drills with an angled handpiece are essential. Silastic film to promote the growth of mucous membrane into spaces to be aerated and Gelfoam to be used as a pack are necessary.

Preoperative preparation

Surgery is made less difficult if oedema and inflammation of the tissues are reduced to a minimum by topical treatment with antibiotics and steroids.

Anaesthesia and position of patient

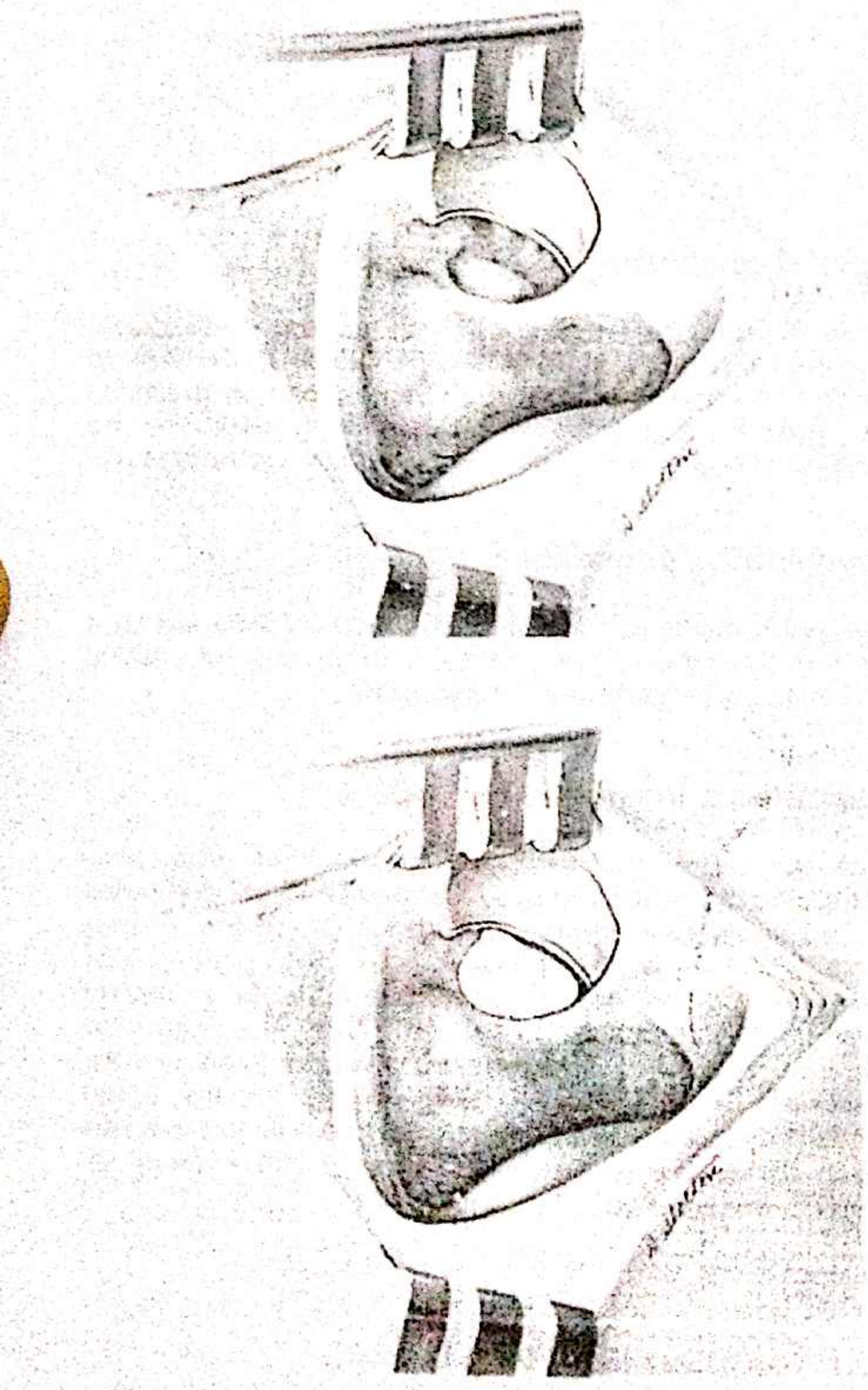
General anaesthesia with an endotracheal tube supplemented by infiltration of a local anaesthetic is preferred since this operation tends to be lengthy and the drilling required can be unpleasant for the conscious patient. The patient is placed on the operating table in a supine position with the head turned to the side. The head is at the foot end of the table so that the surgeon can sit with his knees under the table, unobstructed by the usual support for the headrest. It should be possible to raise and lower the operating table as well as to tilt it away or towards the surgeon.

The operations

The three techniques to manage a troublesome mastoid cavity are: obliteration with muscle; obliteration with bone paté; and reconstruction of the external auditory canal with homograft bone. The prerequisite to each procedure is the complete removal of all disease, the accomplishment of which usually comprises most of the operation.

OBLITERATION WITH MUSCLE

This technique is especially useful for cases with a very active infection and a profusely draining cavity resistant to all forms of medical treatment where the production of a dry ear is the major consideration. All disease must first be removed from the middle ear and mastoid, and a good radical mastoid cavity must be produced. The meatus is enlarged so that all areas will become accessible. The tympanic membrane and external auditory canal are then reconstructed with a large single piece of temporalis fascia. The epitympanum and mastoid cavity are filled with a free temporalis muscle graft. Homograft muscle or fat may also be used. After several months this tissue will shrink and produce a thick fibrous lining for the mastoid cavity over which will grow healthy squamous epithelium. The fibrous layer prevents retraction into the exposed mastoid air cells and gives good support for the covering skin.



2

1

The mastoid cavity is exposed through a postauricular incision. All squamous epithelium is removed from the cavity and middle ear. If some of this skin is good it can be preserved to line the external auditory canal. The meatus is enlarged and the posterior bony canal wall removed so that the entire cavity will be accessible when healing is complete.

2

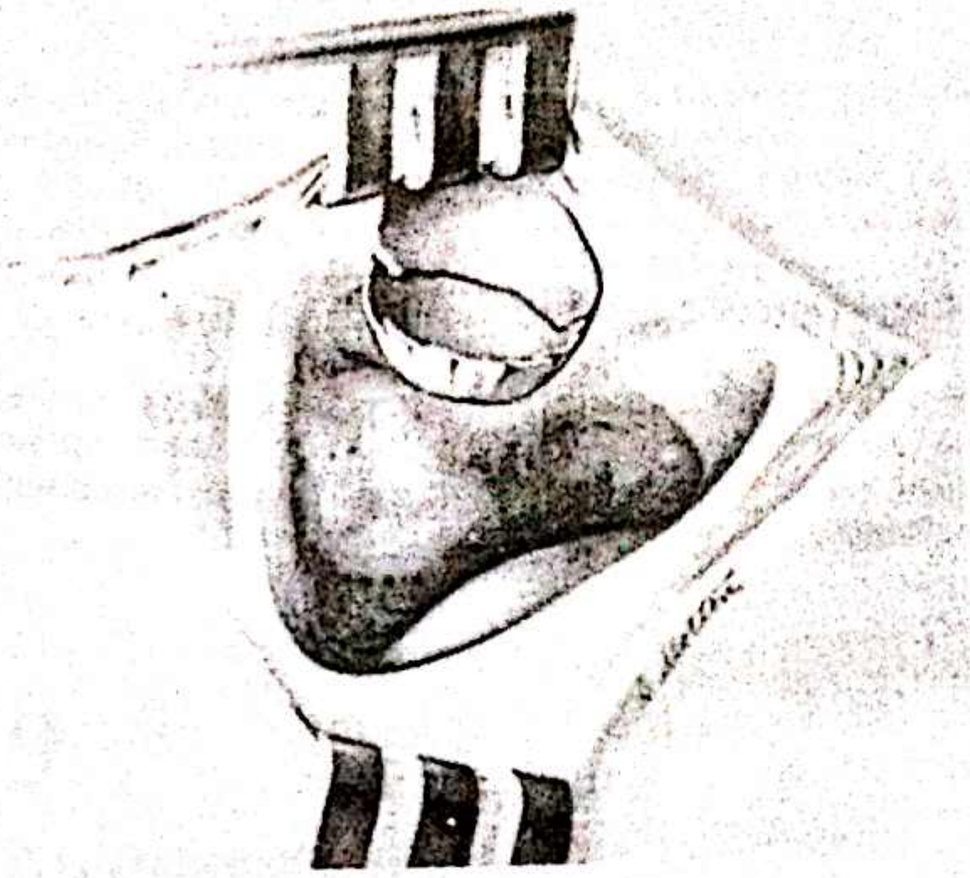
Aeration of middle ear

A disc of heavy Silastic film is fashioned to fit the desired middle ear space. This is placed in the Eustachian tube orifice so that mucous membrane will grow from the tube around the film. Mucous membrane is carefully removed from all areas of the facial ridge and mastoid so that the muscle and fascia will adhere and prevent development of the air space.

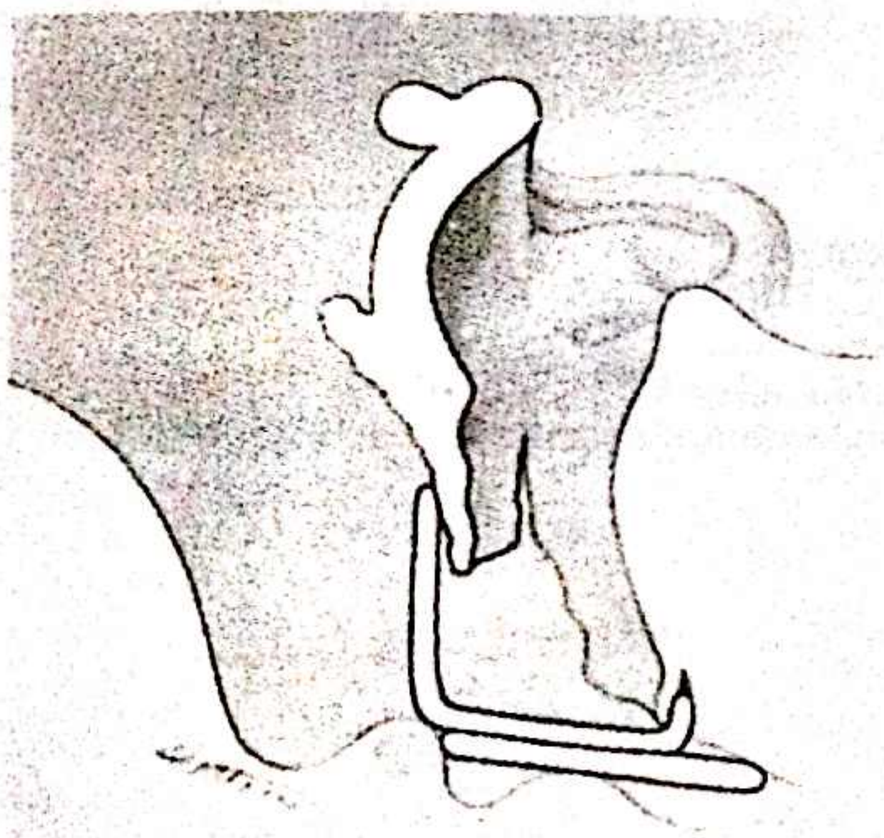
3

Reconstruction of tympanic membrane and external auditory canal

A large single piece of dried temporalis fascia measuring 3 cm in diameter is then moulded to create the new tympanic membrane and external auditory canal. The fascia is overlapped 2 mm by the remaining canal skin. Gelfoam soaked in Otosporin solution is packed over the new tympanic membrane.



3



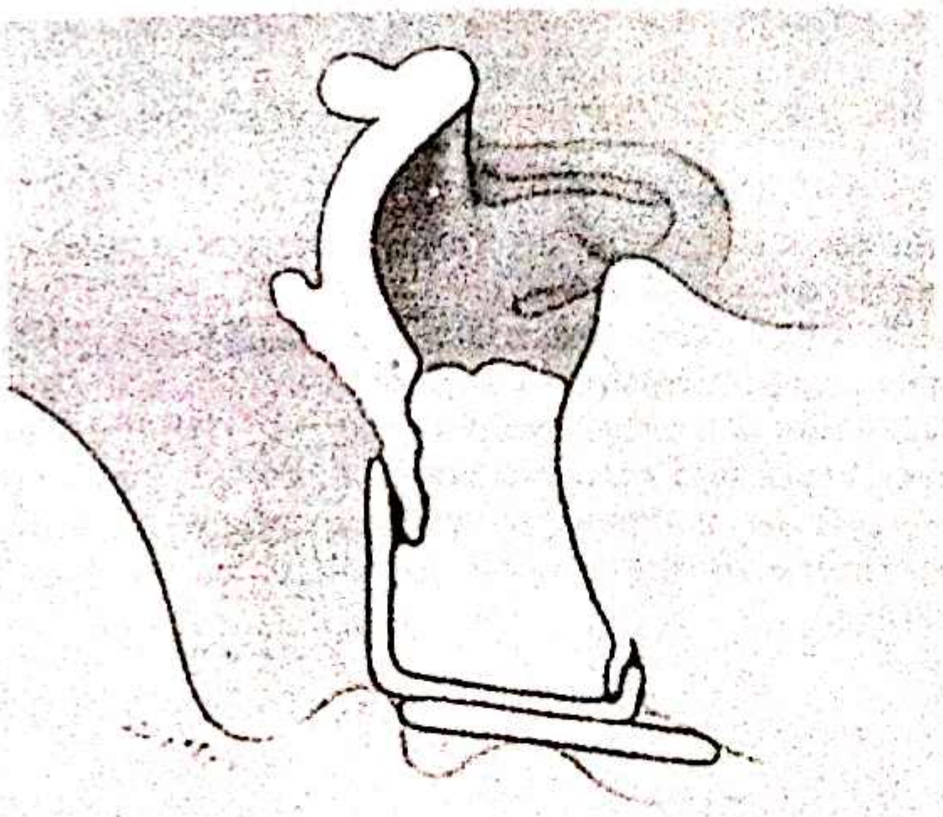
4

4

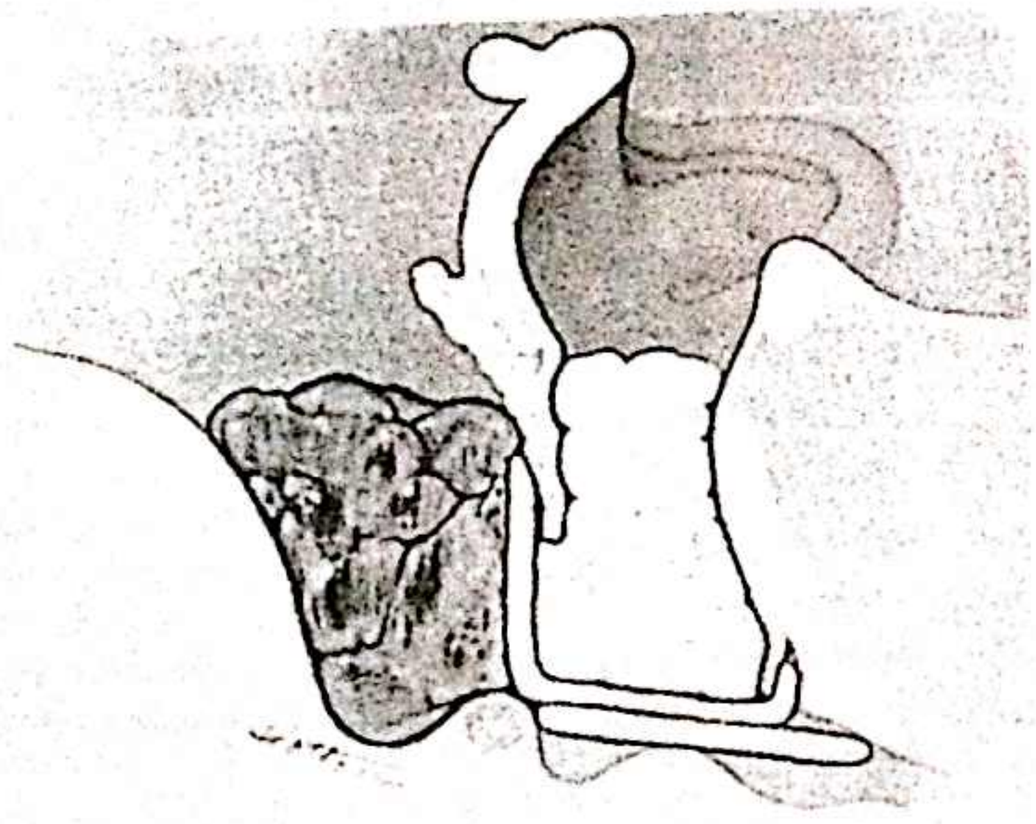
The pinna is allowed to fall back towards its normal position and the remnant of skin of the posterior canal wall is laid into its normal position to cover the fascia.

5

The external auditory canal is filled with Gelfoam soaked in Otosporin to hold the fascia and skin edges in place. Any excess solution is aspirated.



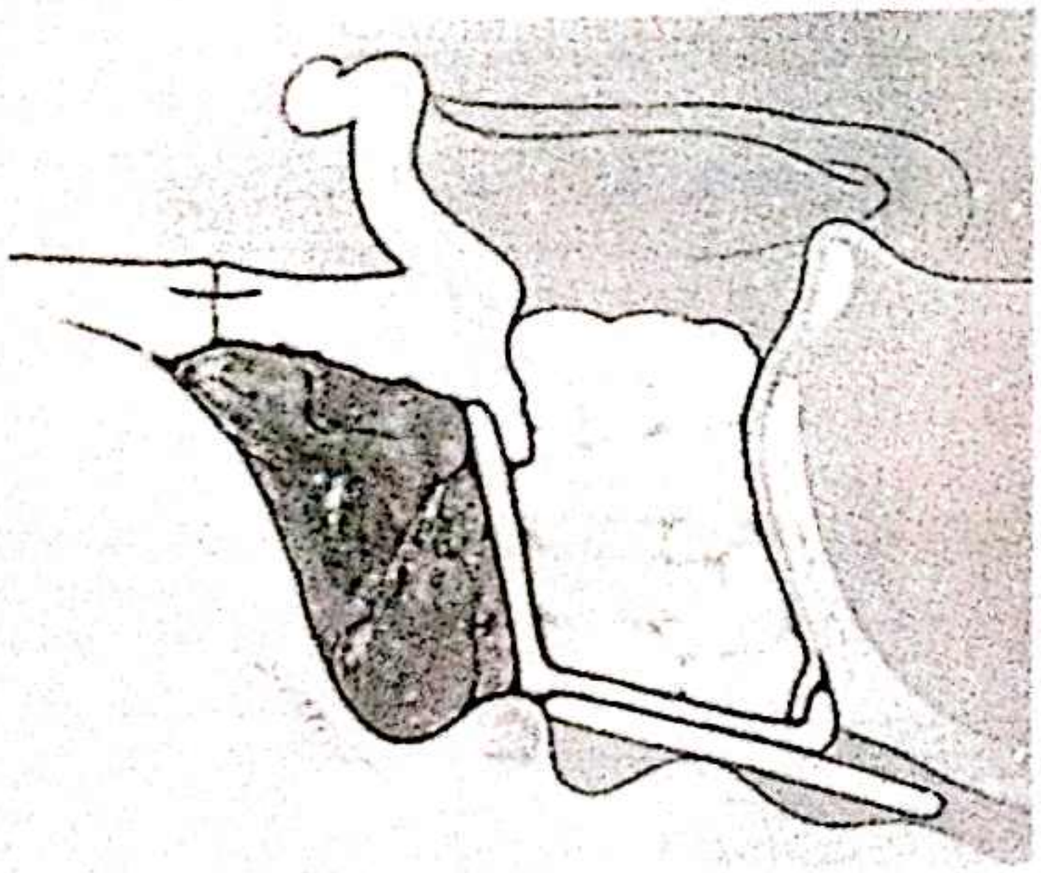
5



6

Obliteration of mastoid cavity

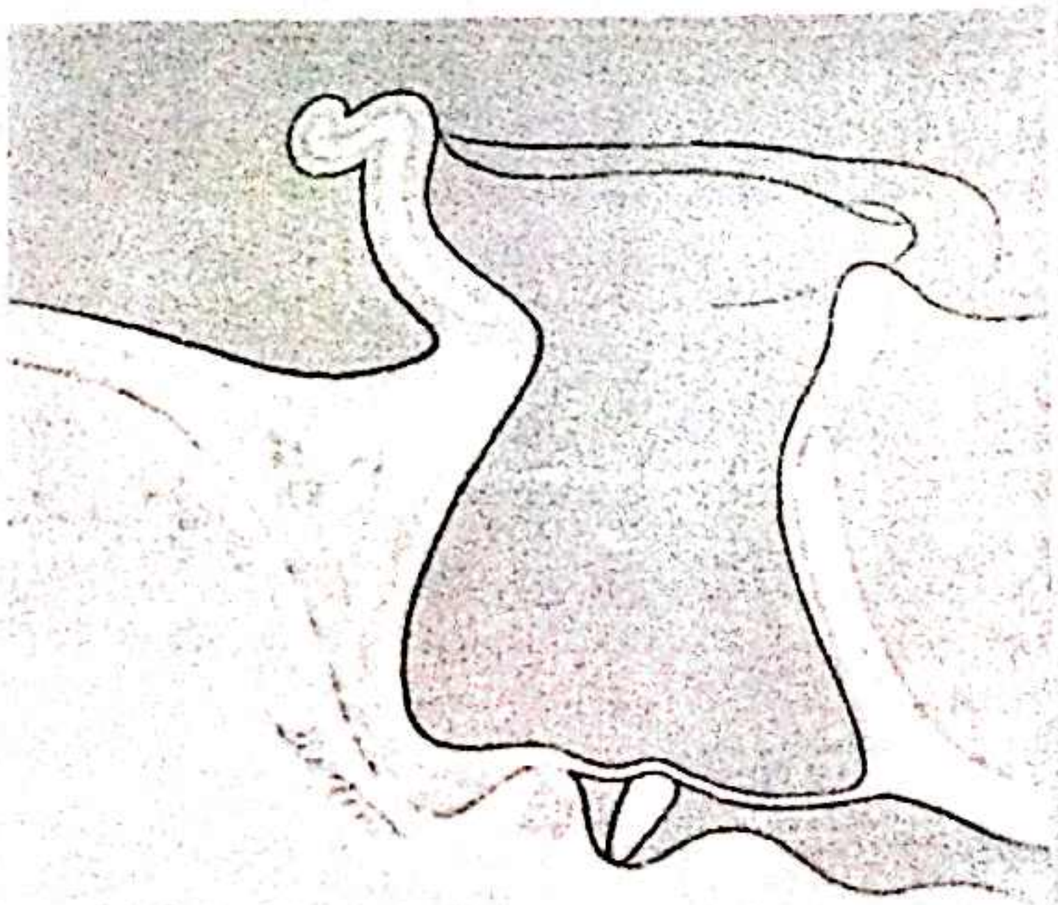
A free graft of temporalis muscle and fascia is then removed and placed in the mastoid cavity and epitympanum. Homograft muscle or fat may be substituted with comparable results.



7

Skin closure

The postauricular incision is closed with a single layer of interrupted subcutaneous 2/0 chromic catgut sutures. A bulky pressure dressing is applied.



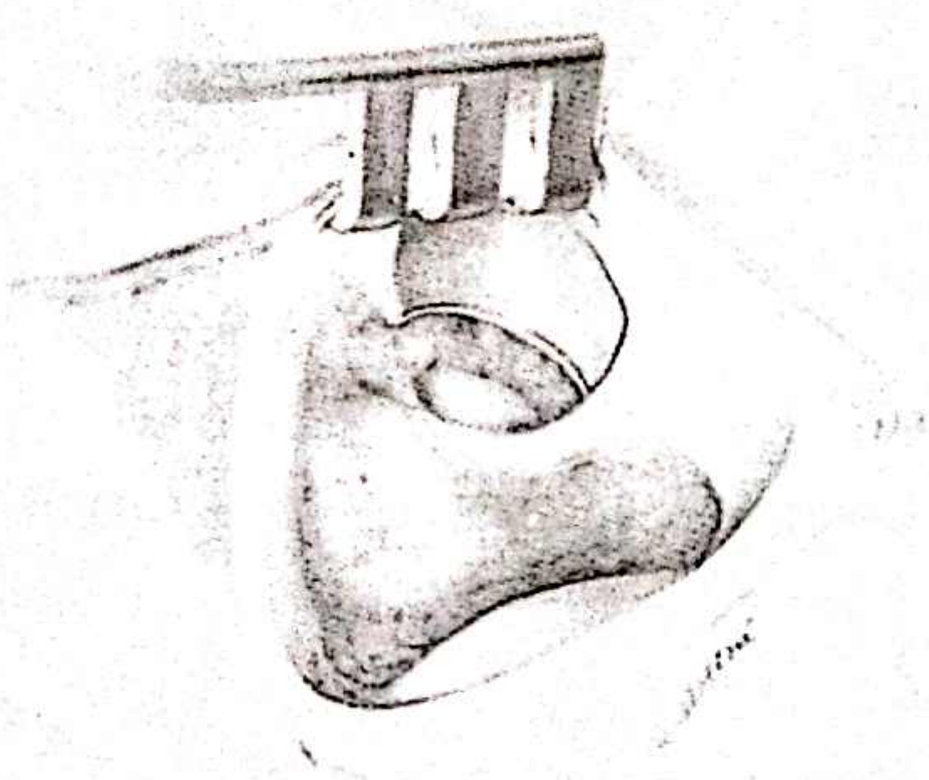
8

After several months the free muscle graft atrophies and retracts. The thick fibrous tissue which remains provides good support for the squamous epithelium lining the cavity and prevents retraction into individual air cells. The silastic film can be removed at a second stage, under local anaesthesia, and a strut of bone or cartilage can be placed between the tympanic membrane and the capitulum of the stapes or the mobile footplate to achieve useful hearing.

OBLITERATION OF MASTOID WITH BONE PATÉ

In cases where active infection and oedematous mucous membrane can at least be temporarily reduced by preoperative topical treatment, the radical mastoid cavity can be permanently obliterated with autograft bone paté. The bone is removed from the surrounding mastoid cortex and squamous portion of the temporal bone. Within a few months it becomes a solid bony posterior external auditory canal and mastoid cortex.

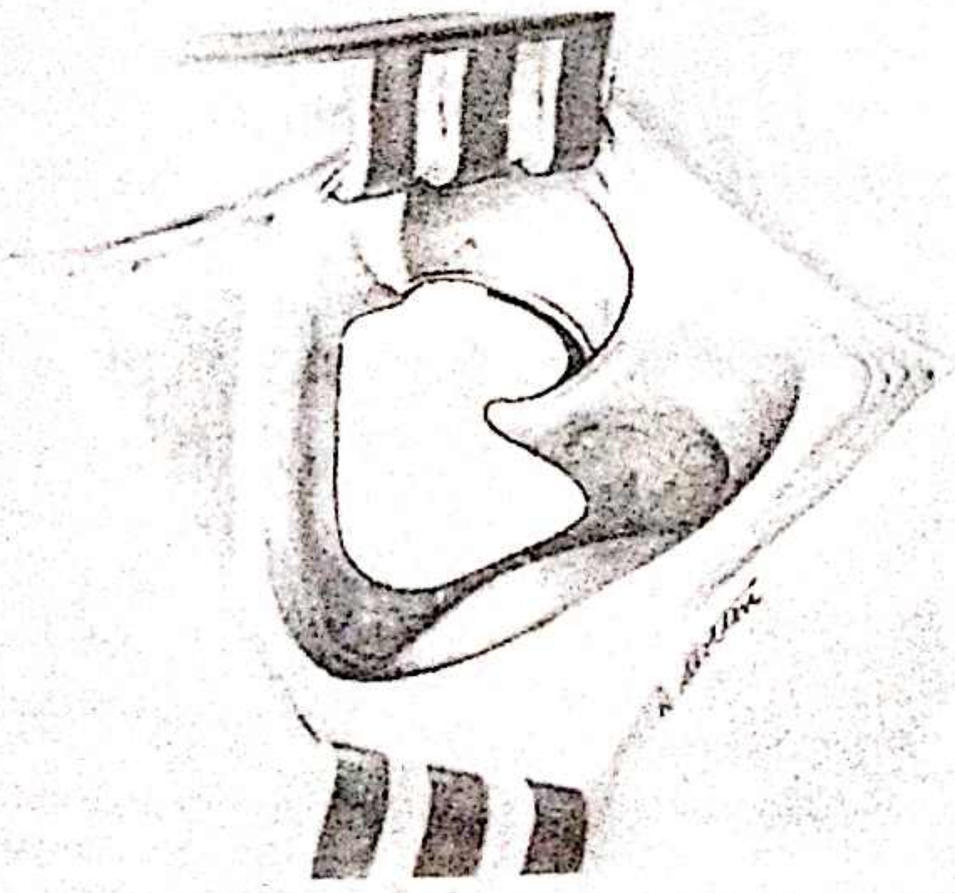
The technique is well suited for repair of the small cavity and for cases where only part of the external auditory canal bone has been removed. It should not be used in the presence of active purulent drainage.



9

Preparation of cavity

All disease must be removed from the mastoid cavity and middle ear. It is not necessary to enlarge the meatus or to remove any additional bony external auditory canal although the facial recess must be opened widely if bone remains in this area.



10

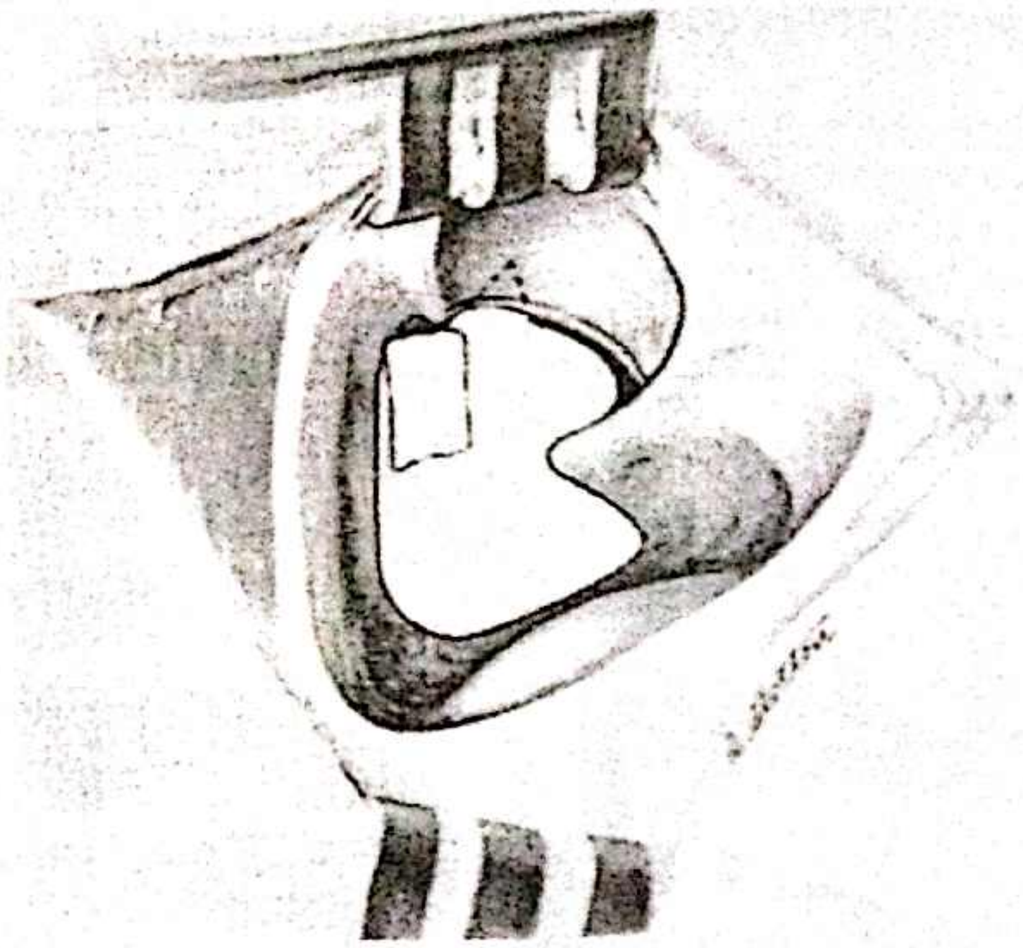
Aeration of middle ear and mastoid

Thick Silastic film is cut in the shape of a 'duck' to conform to the space which is to be lined by mucous membrane. This extends from the Eustachian tube orifice over the middle ear, epitympanum and facial recess, and to the mastoid cavity.

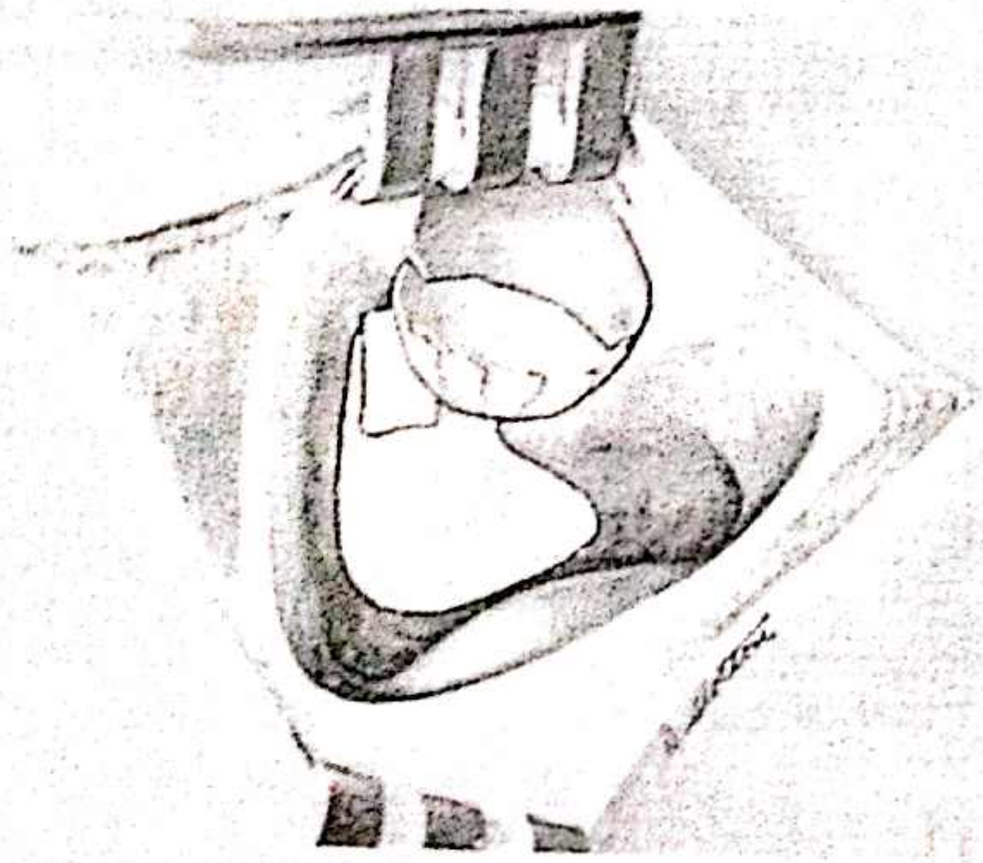
11

Filling of epitympanum

The areas which will become the new epitympanum and incudal fossa are created by placing a block of dry Gelfoam lateral to the Silastic film. This also prevents bone paté from entering the middle ear space.



11



12

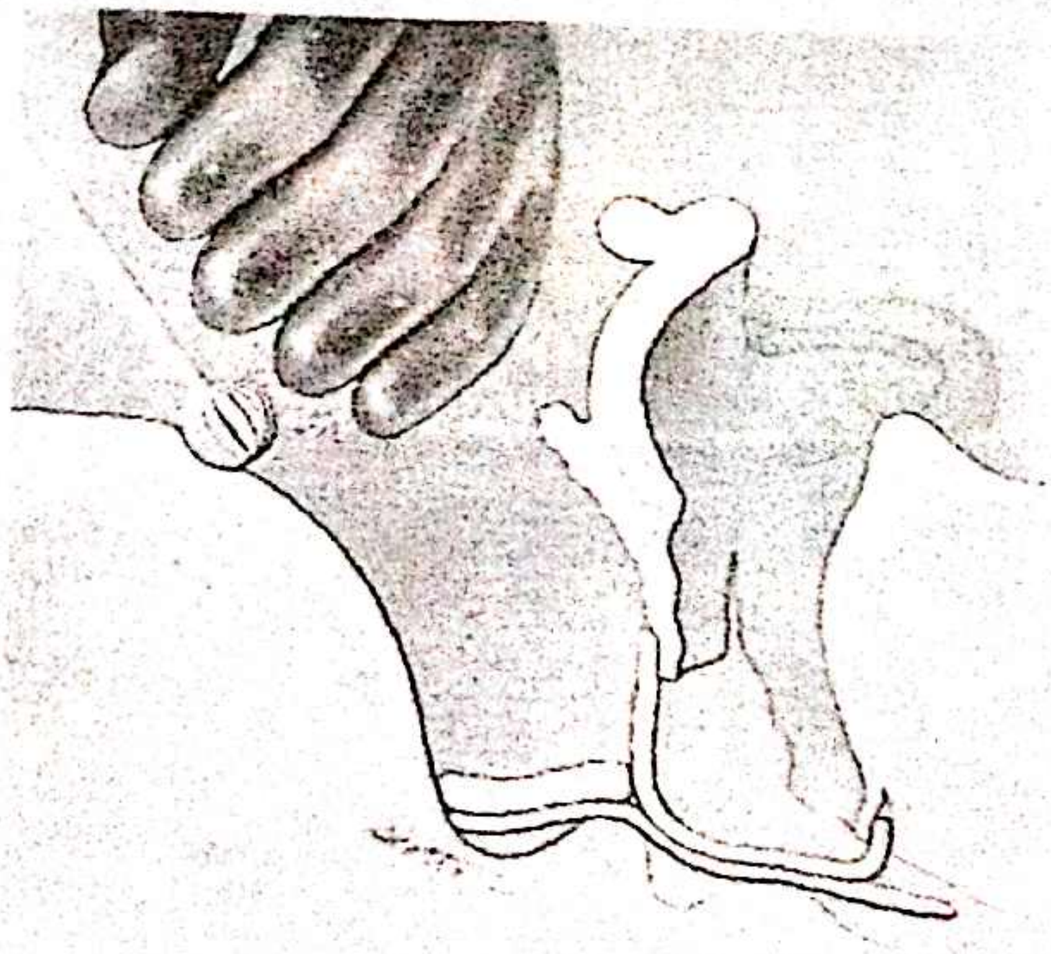
Placement of fascia graft

A dried temporalis fascia graft 3 cm in diameter is moulded to create a new tympanic membrane and external auditory canal. The edges are tucked under the remaining canal skin for 2 mm.

13

Production of bone paté

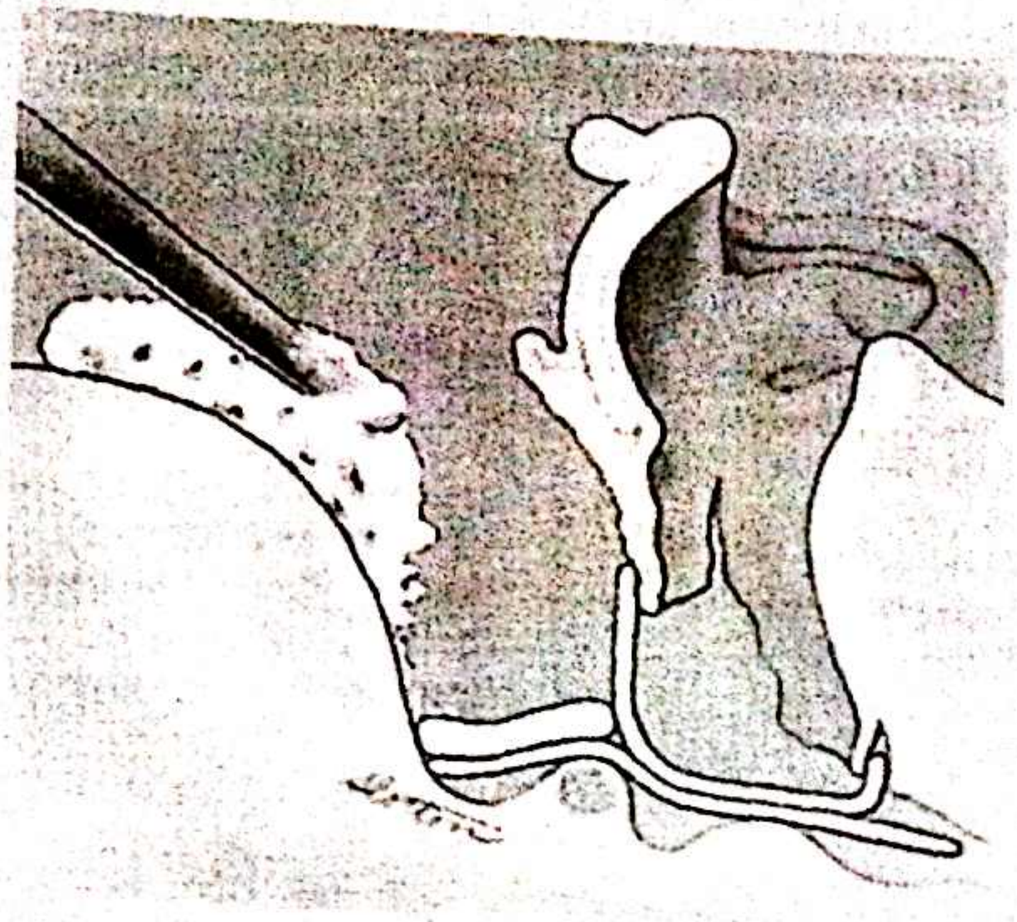
Gelfoam is placed in the area of the antrum to help fill part of the cavity. The pinna is allowed to fall back into position and the remnant of the posterior ear canal skin is placed over the fascia graft. Using the large cutting drill, but without the customary suction-irrigation, the mastoid cortex and squamous portion of the temporal bone are removed. This allows dry bone dust to be produced and at the same time saucerizes and reduces the size of the cavity. The surgeon's hand keeps the bone dust in the area of the cavity.



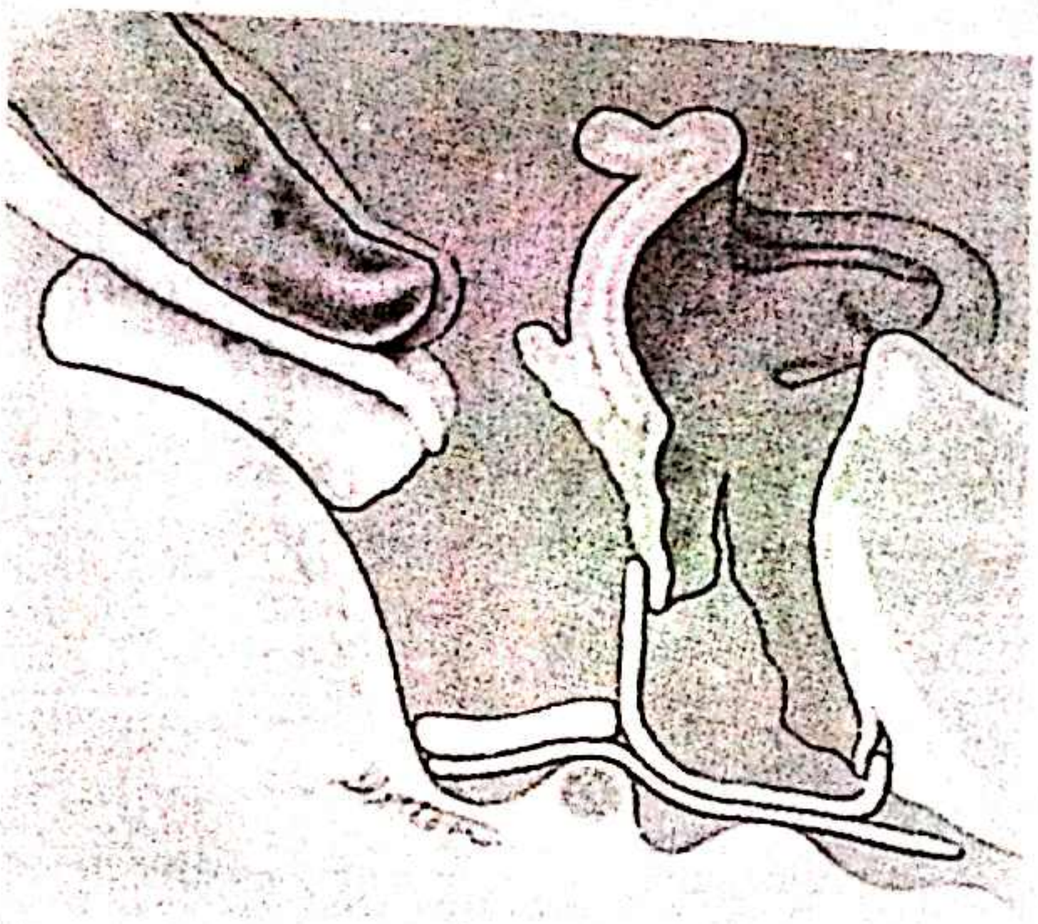
13

14

The bone dust is collected and mixed with blood which seeps from the bone and surrounding muscle.



14



15

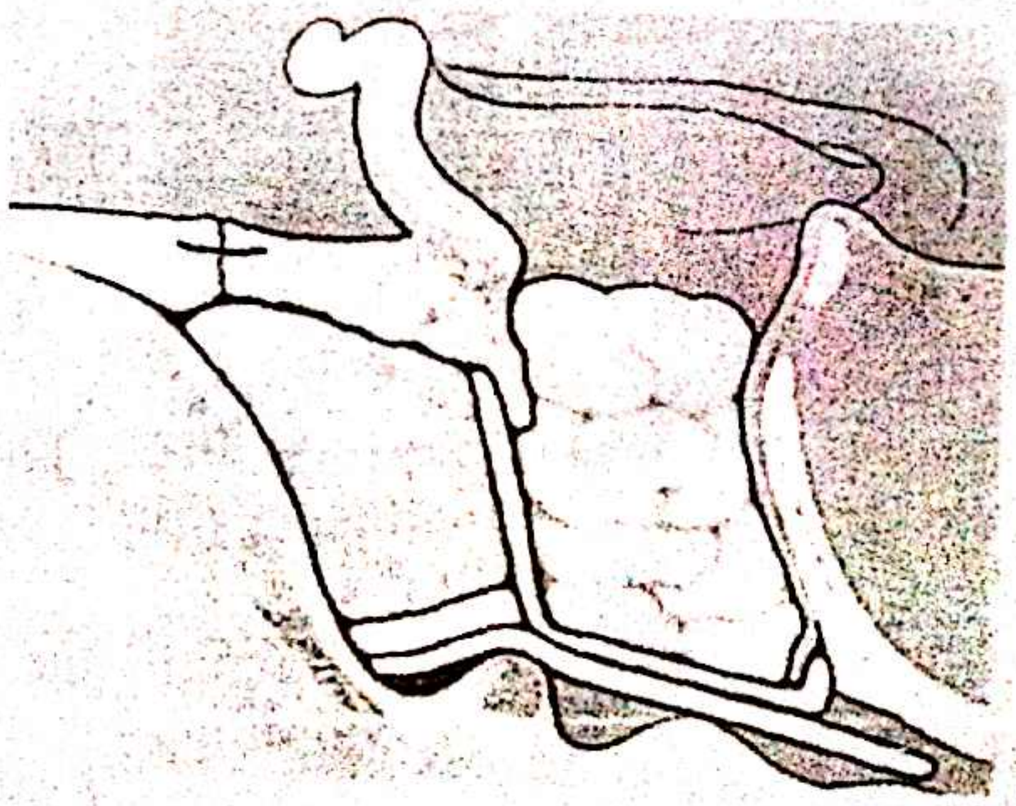
15

The pile of bloody bone paté is blotted with a dry sponge to create a thick 'mortar'.

16

Obliteration of cavity

This bone paté 'mortar' is then packed into the cavity to reconstruct the external auditory canal and mastoid cortex. The wound is closed with a single layer of subcutaneous interrupted 2/0 chromic catgut sutures. Gelfoam soaked in Otosporin solution is packed into the external auditory canal to support the skin edges and the graft. A bulky ear dressing is applied.



16

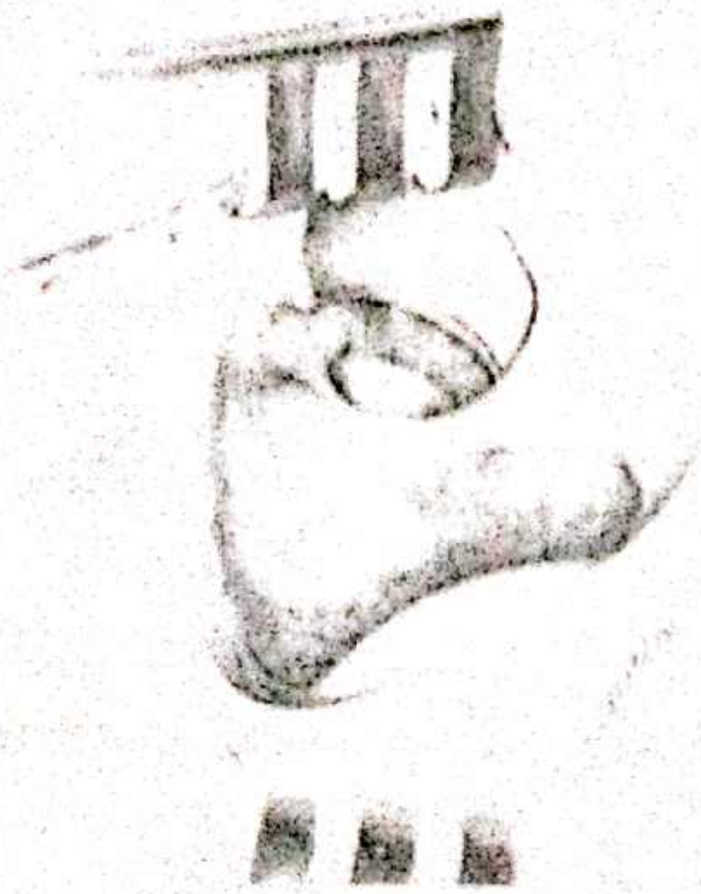
RECONSTRUCTION WITH HOMOGRAFT EXTERNAL AUDITORY CANAL BONE

This technique can only be used in ears which are free of active infection, and is especially useful in the management of very large mastoid cavities or for patients who seek maximum hearing improvement. It requires an experienced surgeon who is familiar with its principles and has mastered the techniques of surgery for chronic otitis media.

The homograft, including the tympanic membrane and ossicles, which may also be used in the reconstuction, is prepared preoperatively and stored in 70 per cent alcohol until use.

All disease must be removed first and the middle ear and mastoid are aerated to prevent retraction into the cavity. All exposed homograft bone is covered with autogenous fascia, as new skin in the ear canal will not migrate over exposed homograft bone as it does on the remainder of the canal.

A second stage reconstruction or adjustment of the ossicular chain, or even stapedectomy with placement of a wire on the homograft incus, can be undertaken after thorough healing.



17

The mastoid cavity and external auditory canal are exposed through a postauricular incision. All disease is removed from the cavity and middle ear. Mucous membrane is preserved wherever possible and no additional external auditory canal bone is removed.

18

Preparation of cavity

Narrow grooves are then made at the superior and inferior edges of the external auditory canal defect in the cavity to accept the new homograft external auditory canal. If the tympanic membrane and anterior annulus of the homograft are to be used, bone must be removed around the area of the annulus to provide adequate space.

RECONSTRUCTION WITH HOMOGRAFT EXTERNAL AUDITORY CANAL BONE

This technique can only be used in ears which are free of active infection, and is especially useful in the management of very large mastoid cavities or for patients who seek maximum hearing improvement. It requires an experienced surgeon who is familiar with its principles and has mastered the techniques of surgery for chronic otitis media.

The homograft, including the tympanic membrane and ossicles, which may also be used in the reconstuction, is prepared preoperatively and stored in 70 per cent alcohol until use.

All disease must be removed first and the middle ear and mastoid are aerated to prevent retraction into the cavity. All exposed homograft bone is covered with autogenous fascia, as new skin in the ear canal will not migrate over exposed homograft bone as it does on the remainder of the canal.

A second stage reconstruction or adjustment of the ossicular chain, or even stapedectomy with placement of a wire on the homograft incus, can be undertaken after thorough healing.

17

The mastoid cavity and external auditory canal are exposed through a postauricular incision. All disease is removed from the cavity and middle ear. Mucous membrane is preserved wherever possible and no additional external auditory canal bone is removed.

18

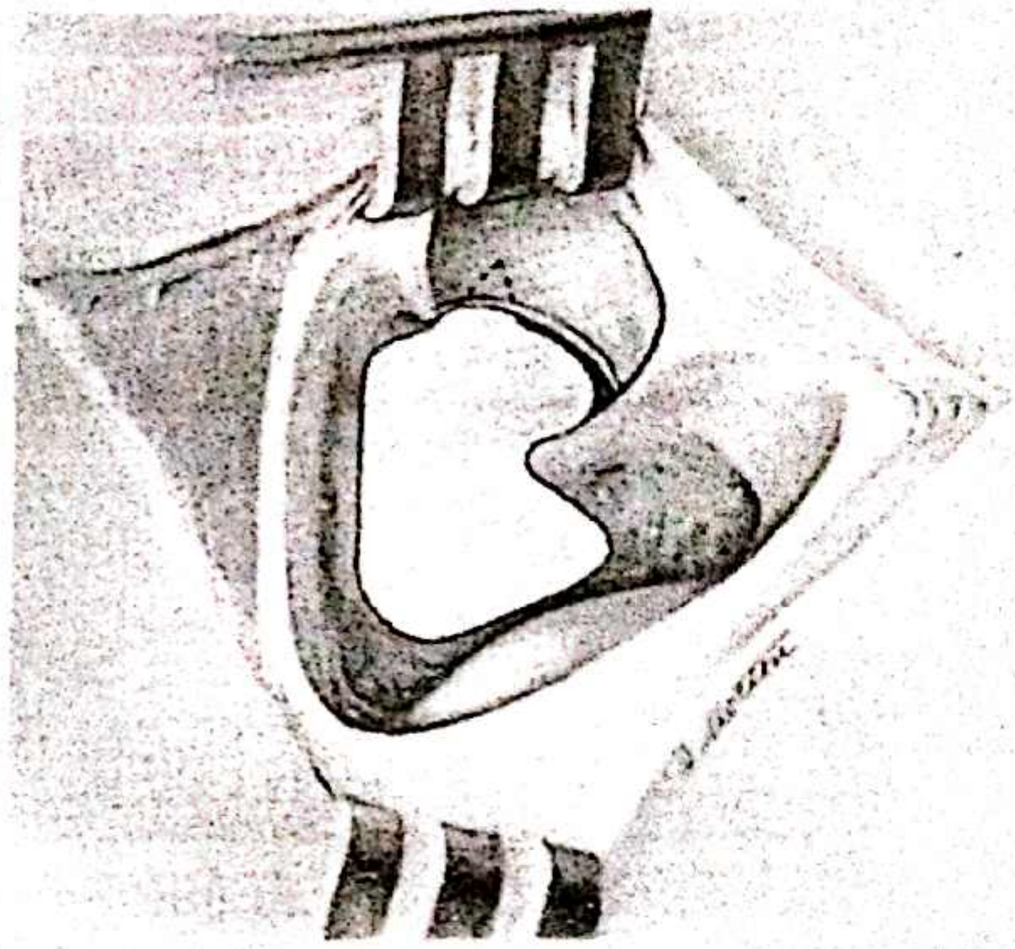
Preparation of cavity

Narrow grooves are then made at the superior and inferior edges of the external auditory canal defect in the cavity to accept the new homograft external auditory canal. If the tympanic membrane and anterior annulus of the homograft are to be used, bone must be removed around the area of the annulus to provide adequate space.

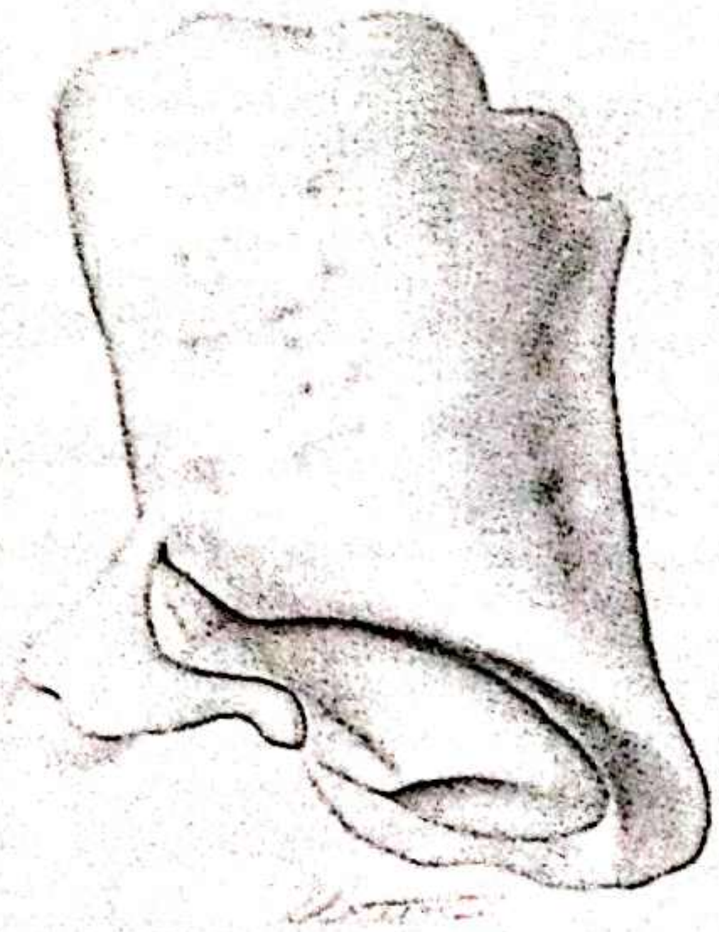
19

Aeration of middle ear and mastoid

Thick Silastic film is cut in the shape of a 'duck' to line the space to be aerated with mucous membrane. This extends from the Eustachian tube orifice, through the middle ear, epitympanum and facial recess, and into the antrum and mastoid.



19



20

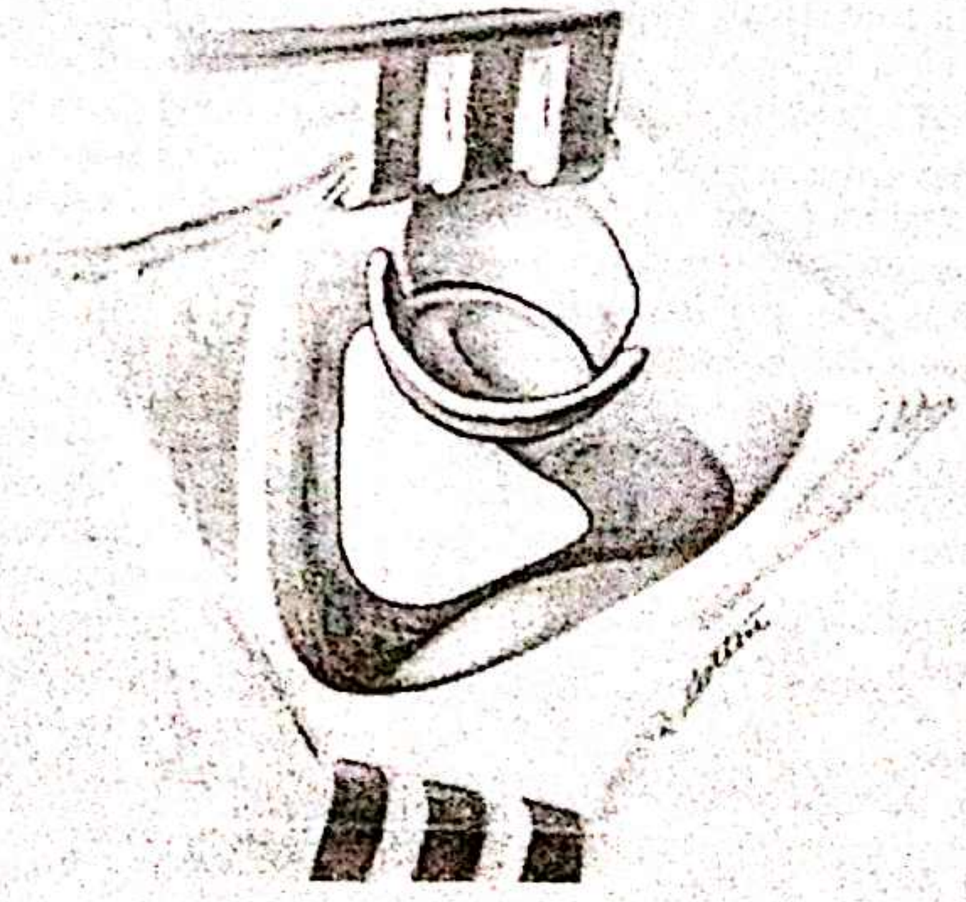
Fitting the homograft

The previously prepared *en bloc* external auditory canal has a thickness of 2 mm. The mobile tympanic membrane, malleus and incus are attached. The graft, which has been stored in 70 per cent alcohol, is briefly rinsed in Ringer's solution immediately before use.

20

21

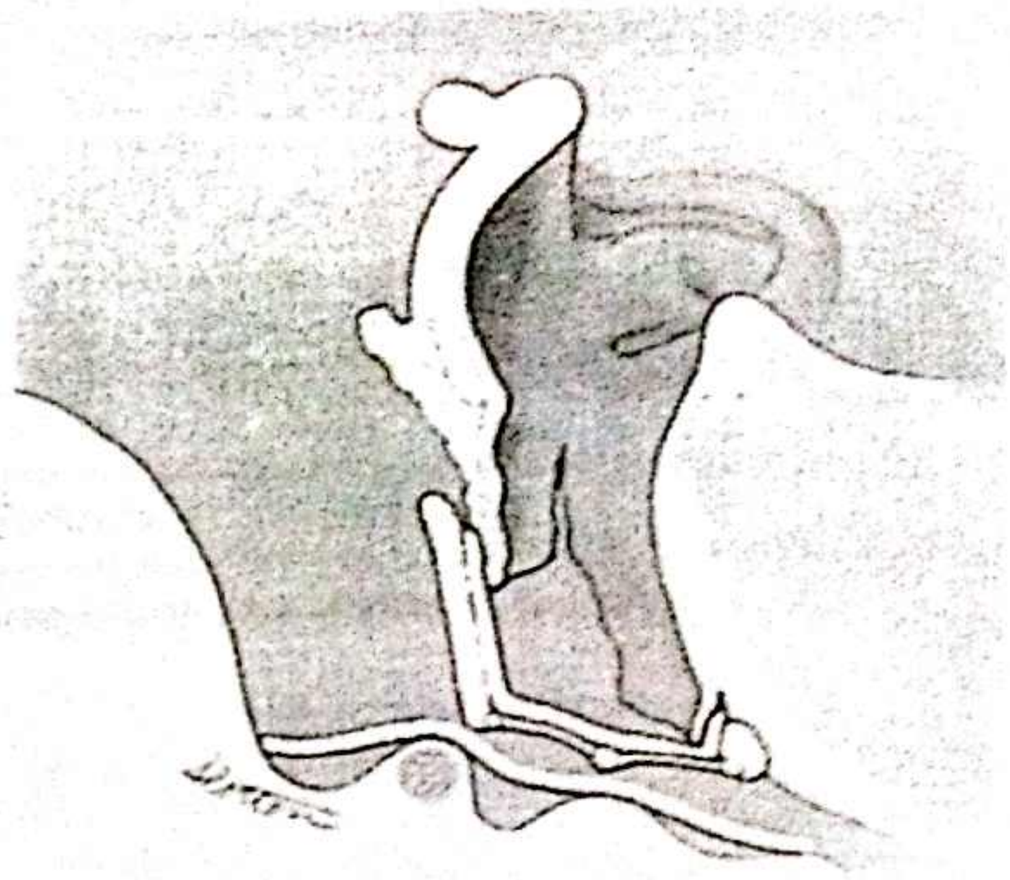
The portion of homograft tissue to be used is determined and then carefully sculptured to fit the recipient site. It is desirable to mortice the graft snugly between the grooves in the mastoid cavity in order to prevent movement. Irregular joints within the ear canal can be corrected with a diamond drill.



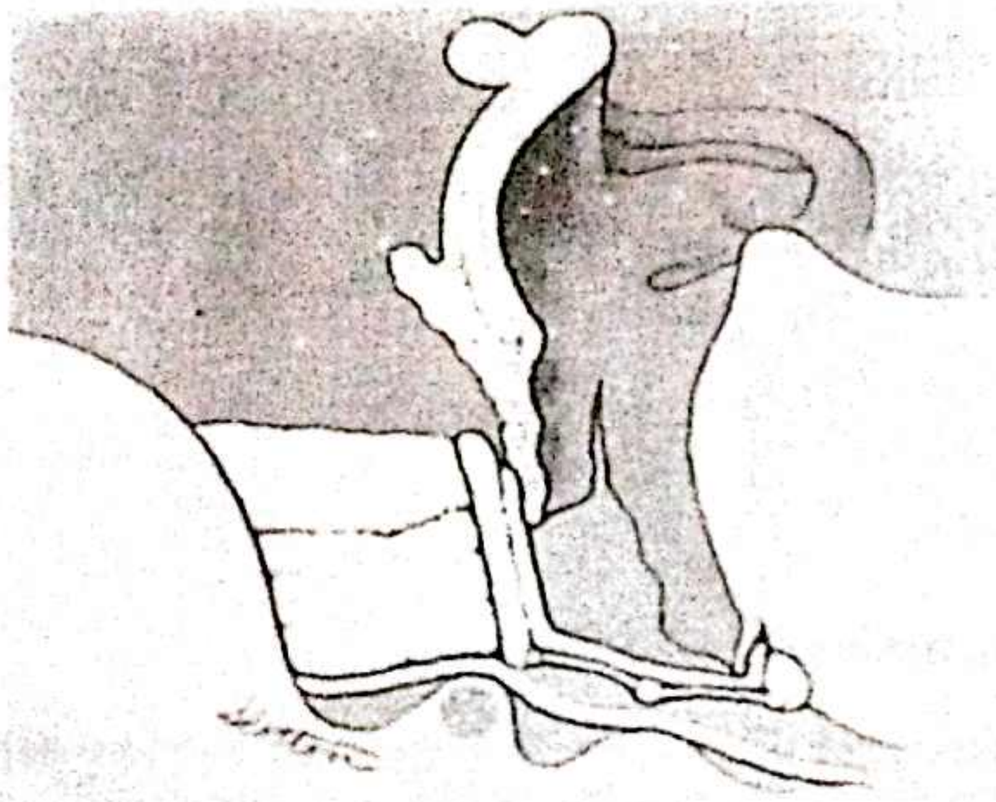
21

22

It is necessary to cover the entire homograft with autograft fascia and overlap the fascia with the skin edges to promote successful growth over the raw area.



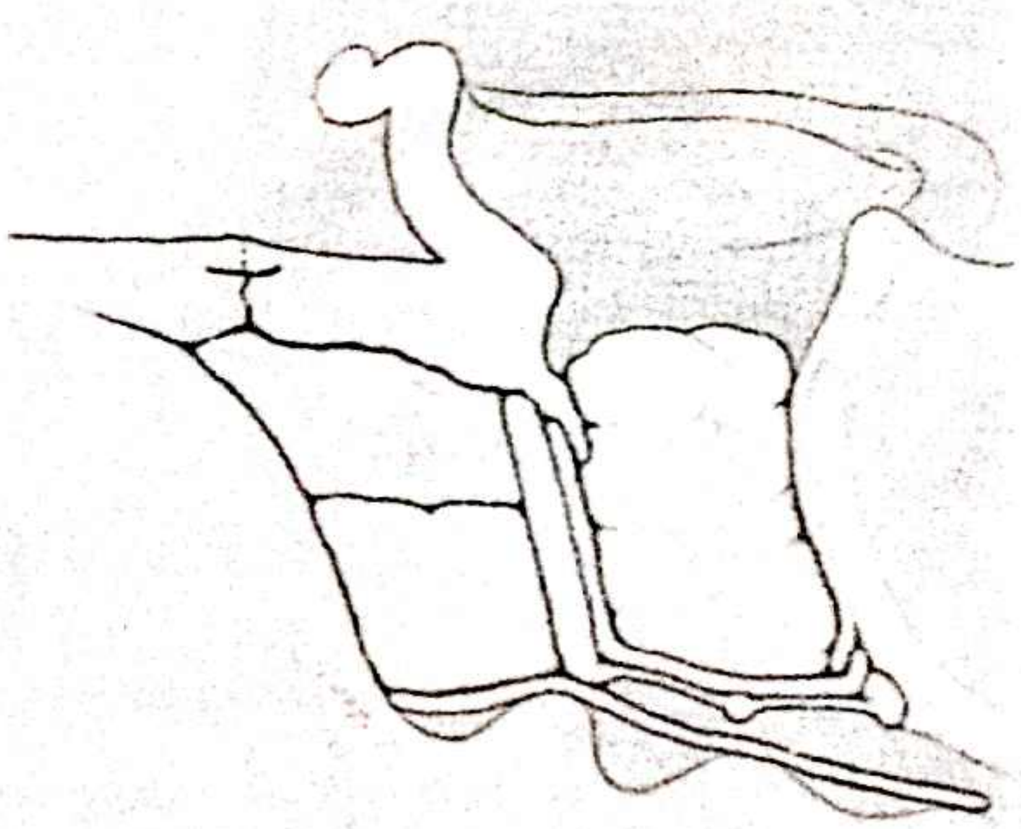
22



23

23

The mastoid cavity is filled with moist Gelfoam which will later dissolve to form an air space. Bone paté removed from the surrounding cortex is placed over the bone joints of the homograft and the mastoid cavity and is placed over the Gelfoam to reconstruct the mastoid cortex and to support the lateral edge of the homograft.



24

24

Closure

The skin incision is closed with a single layer of interrupted subcutaneous 2/0 chromic catgut sutures. The ear canal is packed with Gelfoam soaked in Otosporin solution. A bulky ear dressing is applied.

Postoperative care

Sulfasoxazole (sulphafurazole) is given orally for 12 days following operation. The head dressing is removed the day after surgery and the patient is discharged from the hospital on the second postoperative day. He is instructed to instil two drops of an antibiotic and steroid medication into the ear four times daily, beginning after 3 weeks. The ear drops remove any remaining Gelfoam packs or blood clots so that when the tympanic membrane is first examined 4 weeks postoperatively the ear canal is usually clean and well healed. Should a problem area be present, continued medical treatment or minor surgical revision may be necessary. Secondary reconstruction of the ossicular chain is best accomplished under local anaesthesia by the transcanal approach after an interval of months.

Illustrations by Gillian Lee

Obliteration of the mastoid cavity

Tauno Palva MD
Professor of Otorhinolaryngology, University of Helsinki, Helsinki, Finland

Preoperative

Indications

Obliteration of the mastoid cavity may be required in several of the surgical procedures used to treat infective diseases of the ear. I started using mastoid obliteration in the early 1950s in children with recurrent mastoiditis. By occluding the antrum with a musculoperiosteal flap, the middle ear was separated from the mastoid and spread of infection from the tympanic cavity to the mastoid area prevented.

Mastoid obliteration is also indicated in non-cholesteatomatous ears in which mastoidectomy must be performed in addition to tympanoplasty or simple myringoplasty because of an inflammatory process in the mastoid. There may be signs of an active or quiescent osteitis, or a latent disease process associated with granulation tissue, cholesterol granuloma and fluid in the cellular system. Obliteration is advisable in all cases in which there is any doubt about the integrity of Eustachian tube function, as defective tubal function may lead to tympanic fibrosis and adhesion formation, increasing the risk of a retraction pocket developing between the posterior tympanic membrane area and the fibrosing mastoid.

The main indication for obliteration of the mastoid bowl is cholesteatoma extending backwards beyond the facial nerve. Limited cholesteatomatous disease can be eradicated by endaural tympanoplastic surgery; there is no need to open the mastoid. However, such limited procedures account for less than 10 per cent of the cases operated on in our hospital, and obliteration surgery is performed in the great majority of cholesteatomatous ears.

Obliteration is also the treatment of choice for a discharging and granulating old open mastoid cavity. Conversion of such a cavity into a large ear canal in conjunction with tympanic reconstruction effectively rids the patient of a difficult and possibly dangerous condition.

Investigations and preparation of patient

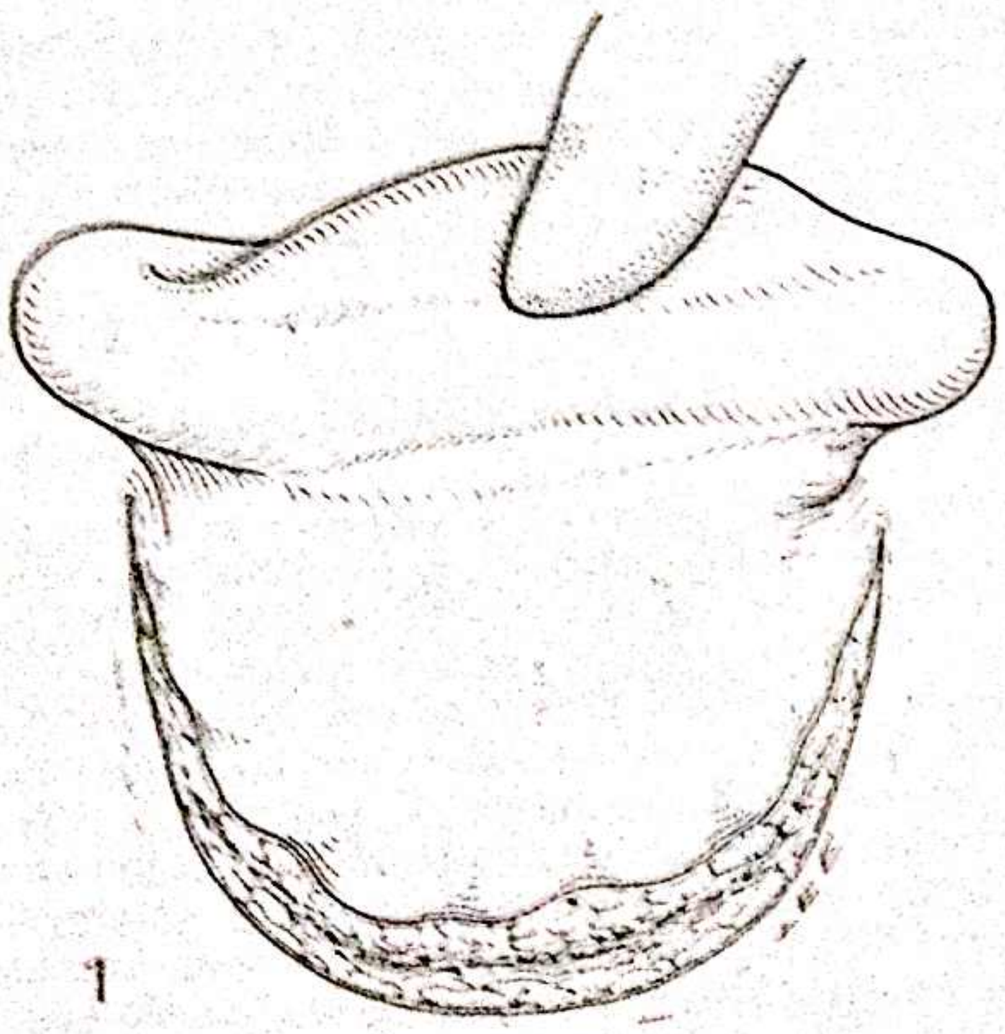
Bacteriological examination is essential when surgical treatment of a moist or discharging ear is contemplated. If the ear has been treated locally with antibiotic ear drops, it may be advisable to secure a second culture for fungi and yeasts. For 2–3 weeks before surgery, the external ear canal is irrigated once a week with warm saline solution in order to remove all pus and debris, and painted with 0.5 per cent gentian violet. This treatment is repeated on the day before surgery when the patient is admitted to hospital. Systemic antibiotic therapy is now instituted, using the agent judged most appropriate on the basis of sensitivity tests. If the culture has yielded only yeasts or fungi, no antibiotic is given. Antibiotics can also be omitted if the ear is dry. The patient generally remains in hospital for 6 or 7 days after surgery and antibiotic treatment is continued over this period. The serum creatinine concentration must be measured if drugs belonging to the aminoglycoside group are given. If kidney function is impaired, daily determination of the serum level is mandatory.

Radiographic examination of the ear is carried out on the day before surgery at the latest. This provides essential information about the amount of tissue required for

obliteration of the mastoid and also assists the surgeon in identifying any anatomical features relevant to the operation (e.g. location of the sinus wall, down-hanging dural plate, abnormalities in the course of the facial nerve).

Since controlled hypotension is an essential requirement in surgery involving elaborate middle ear reconstruction, the anaesthetist is asked to examine the patient the day before surgery. Any patient with a history of cardiovascular or pulmonary disease should be examined by the anaesthetist a few weeks before surgery and, if necessary, a physician's opinion should be sought.

Hearing tests for speech and pure tones are carried out the day before surgery, after the surgeon has inspected and cleaned the ear. This should be done even if hearing has been tested only a couple of months earlier, so that any unexpected deterioration in hearing can be detected preoperatively and the surgeon is not blamed for a hearing loss that he has not caused. We also carry out a sonometric examination of Eustachian tube function in all patients except children who are too young to be able to cooperate.



1

The actual preparation for surgery includes shaving off the hair 5 cm around the ear. Immediately before surgery the ear is cleaned with 70 per cent alcohol. The ear canal itself is not cleaned, as it was painted with 0.5 per cent gentian violet solution the day before.

Anaesthesia

General anaesthesia with endotracheal intubation is used and, unless contraindicated, hypotension is induced when surgery has proceeded to the middle ear. This is maintained throughout surgery. If nitrous oxide is given, it should be turned off at least 5 minutes before the tympanic cavity is closed to prevent the anaesthetic gases from ballooning the tympanic membrane graft out of its proper position.

The postauricular area is infiltrated with 0.5 per cent lignocaine (lidocaine) with adrenaline solution. It is especially important to infiltrate the canal skin so as to make it thick and easy to handle during surgery.

The operation

The incision

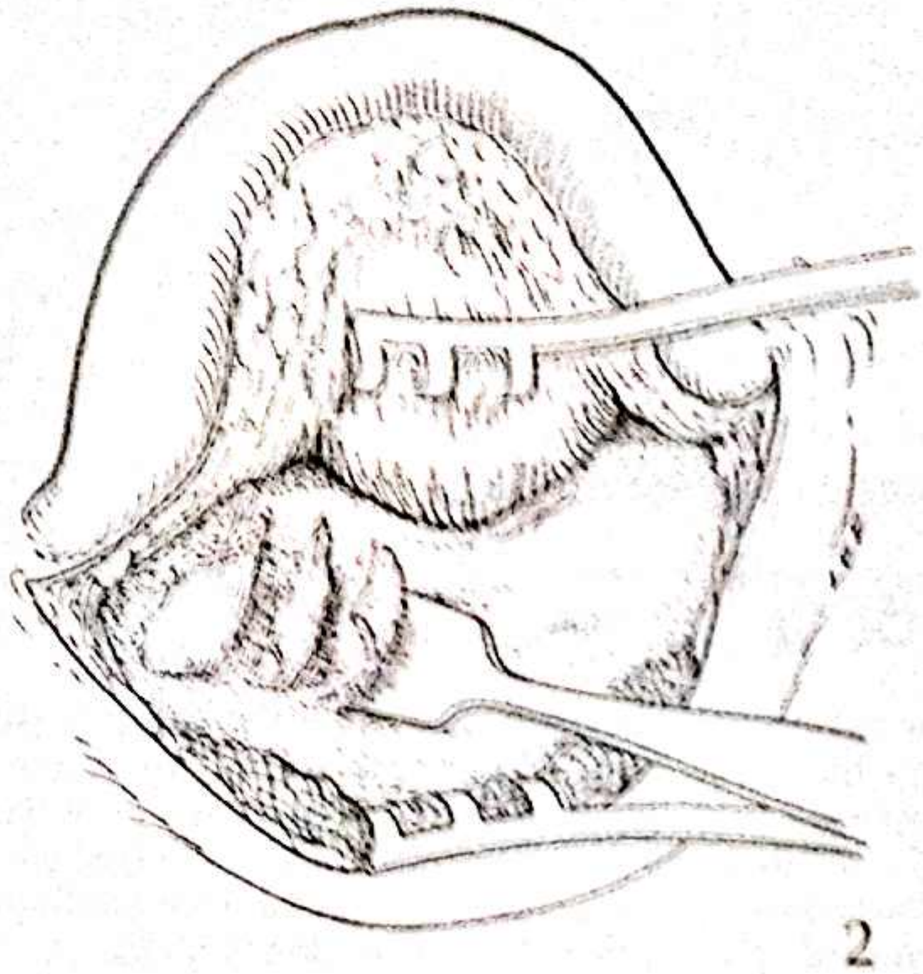
1

A curved postauricular incision is made 2 cm behind the postauricular sulcus through the skin only. The incision should extend from the upper insertion of the auricle superiorly to the mastoid tip inferiorly. The incision margins are undermined anteriorly as far as the attachment of the auricle and posteriorly 3–4 cm posterior to the incision. The skin is retracted posteriorly and the incision deepened to the bone, starting from above, turning 90° to reach the level of the mastoid tip, and then turning 90° again to complete the incision anteriorly at the lowermost part of the conchal insertion. The flap is dissected towards the auricle. The periosteum is left to cover the bone at the posterior part, but from the posterior border of the lateral sinus onwards it is included in the flap. The flap which consists of subcutaneous tissue, muscle and periosteum remains attached meatally so that it receives its blood supply both inferiorly and superiorly and its nerve supply from the postauricular branch of the facial nerve. Haemostasis is achieved with bipolar cautery, a roll of gauze is placed under the posterior skin margin and a retractor is inserted.

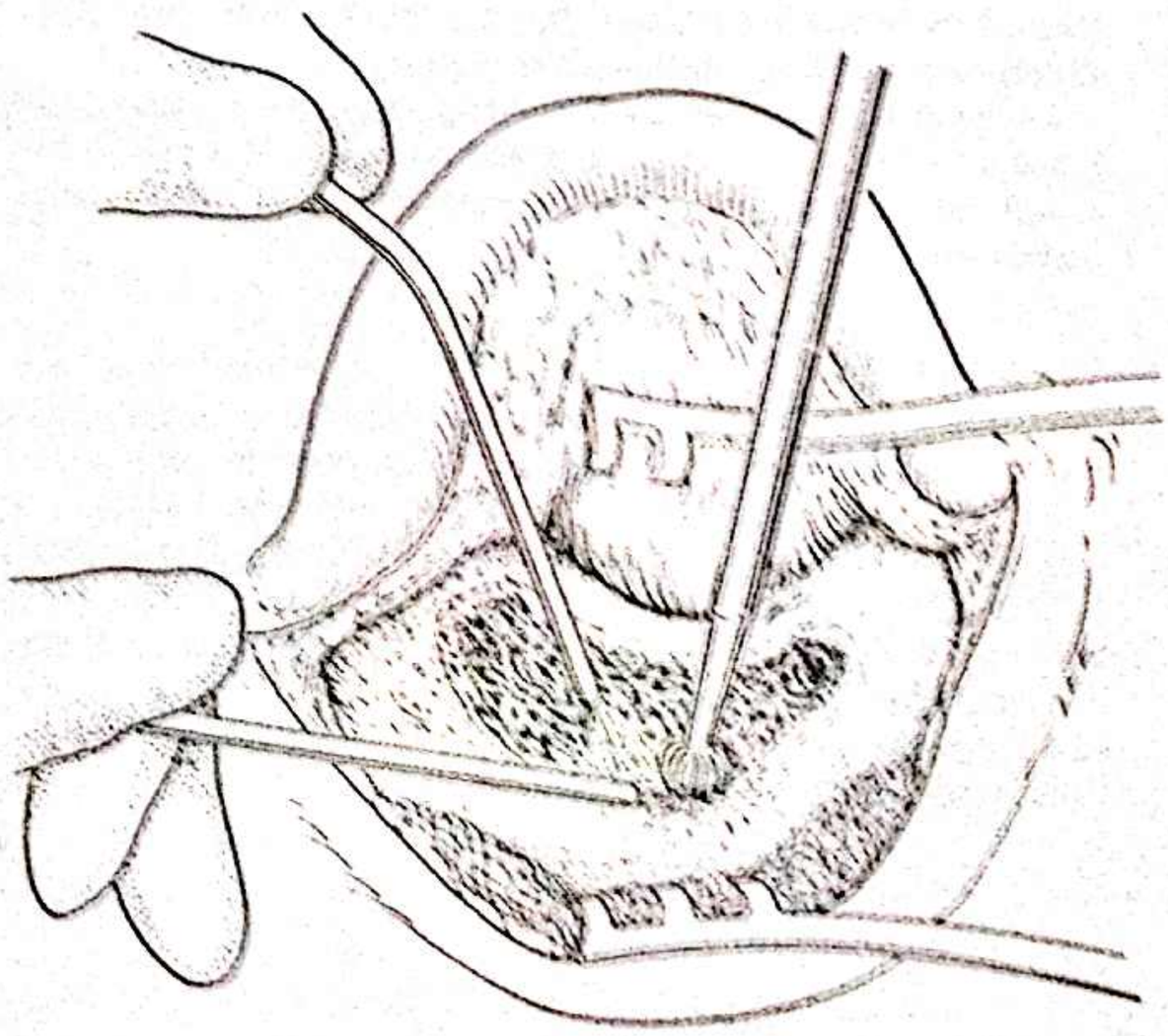
Collection of bone chips and bone paté

2 & 3

Periosteum-containing bone chips are chiselled from the mastoid tip area with a thin, broad chisel and a mallet. In order to facilitate the removal of bone chips, a broad knife can be used to cut the attachments to the sternomastoid muscle. The muscle chips are stored in physiological saline solution. Bone paté is drilled from the solid mastoid cortical bone and, if a large amount is needed, also from the bone on the temporal lobe and the bone behind the lateral sinus. It is advisable to use a special collector (Chesebrough Ponds, Inc., Connecticut, USA) which keeps the bone paté at its bottom even when strong suction is applied. Irrigating saline should be used liberally and, in order to avoid inclusion of metallic particles, care should be taken not to touch the suction tip with the drill. The bone paté is stored in a jar containing ampicillin solution until required.



2



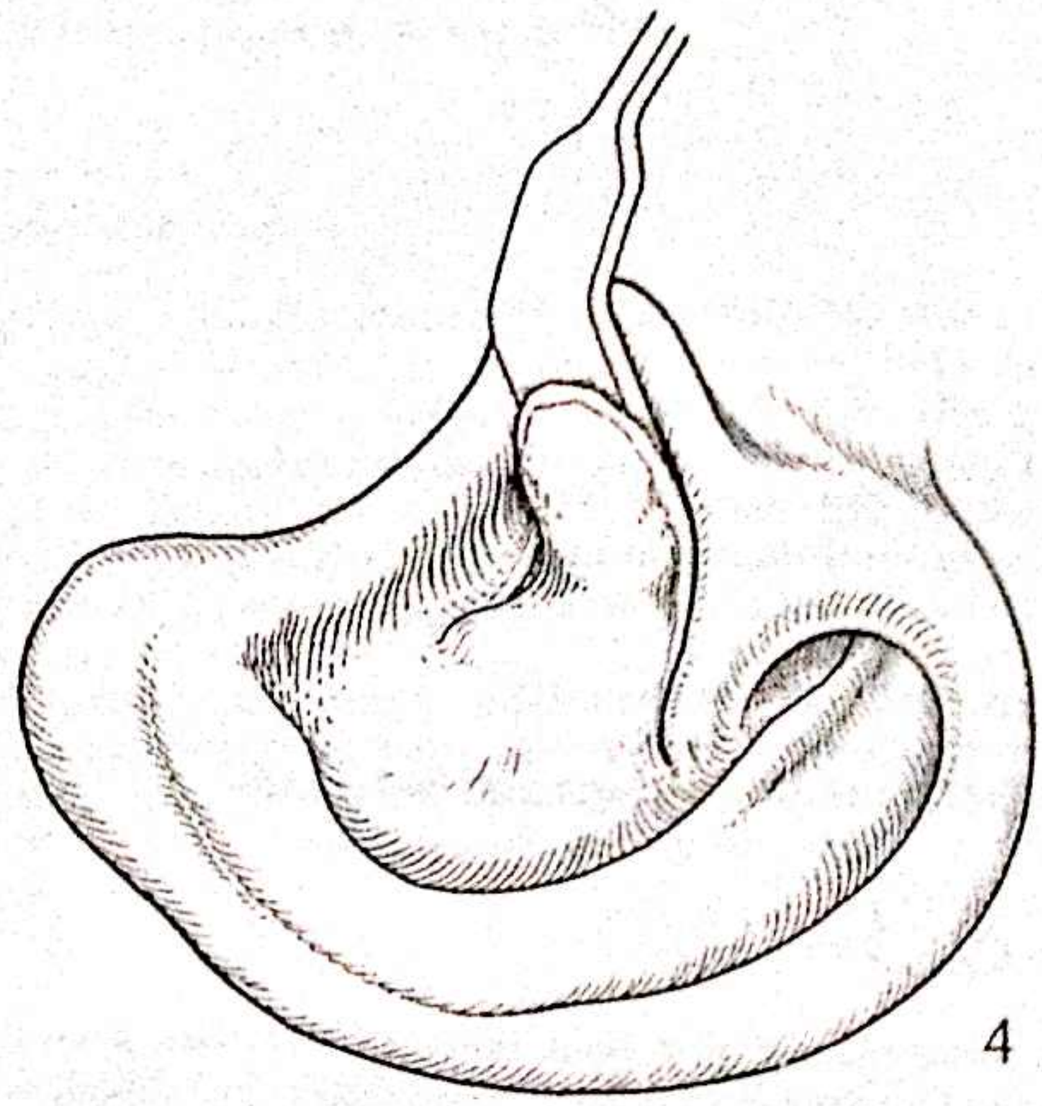
3

Endaural meatoplasty

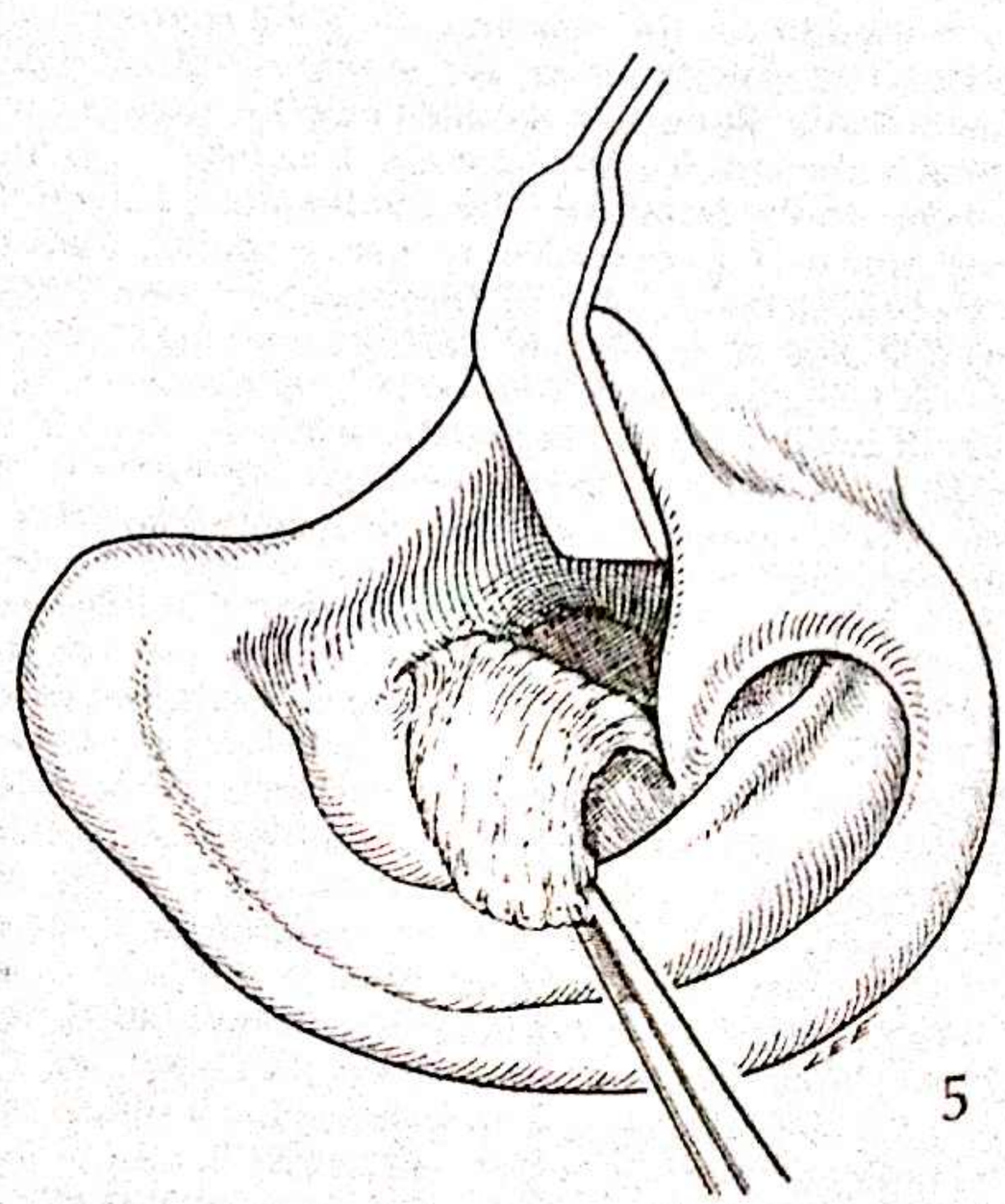
4 & 5

If the external ear canal is narrow, a meatoplasty should always be performed, either at this stage or as the first preliminary step. A transverse incision is made in the ear canal 1 cm from the outer entrance and extended laterally both inferiorly and superiorly so that conchal cartilage can be excised to a depth of 1 cm. The skin is lifted out of the meatus and dissected free of the cartilage, which is excised beyond the upper and lower skin margins. The underlying soft tissues are cut down to the bone to allow them to be turned down into the ear canal with the skin flap. The meatal cartilage can be stored with the bone chips and used as obliteration material.

Large ear canals need no meatoplasty. In medium-sized canals it is often possible to make relaxing incisions in the canal skin up to the cartilage margins to create a wider entrance.



4

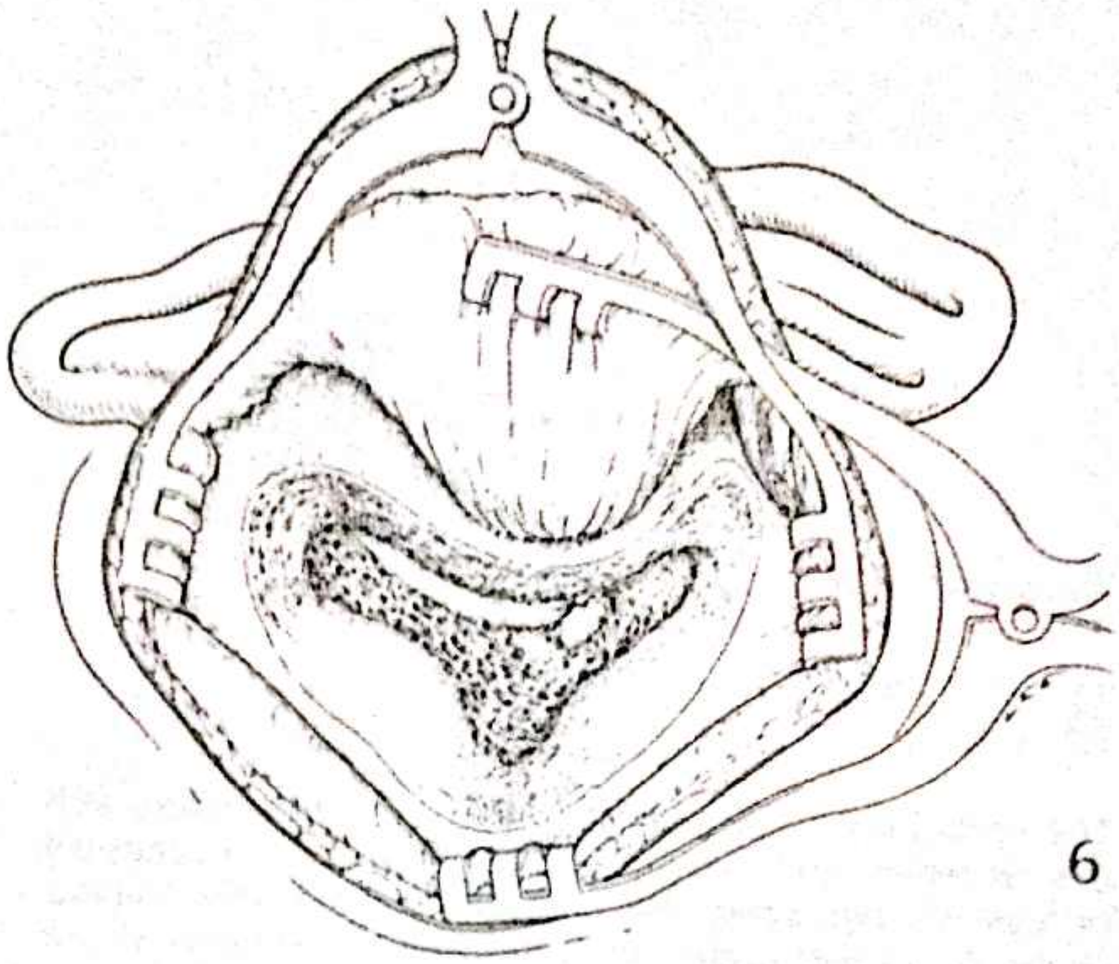


5

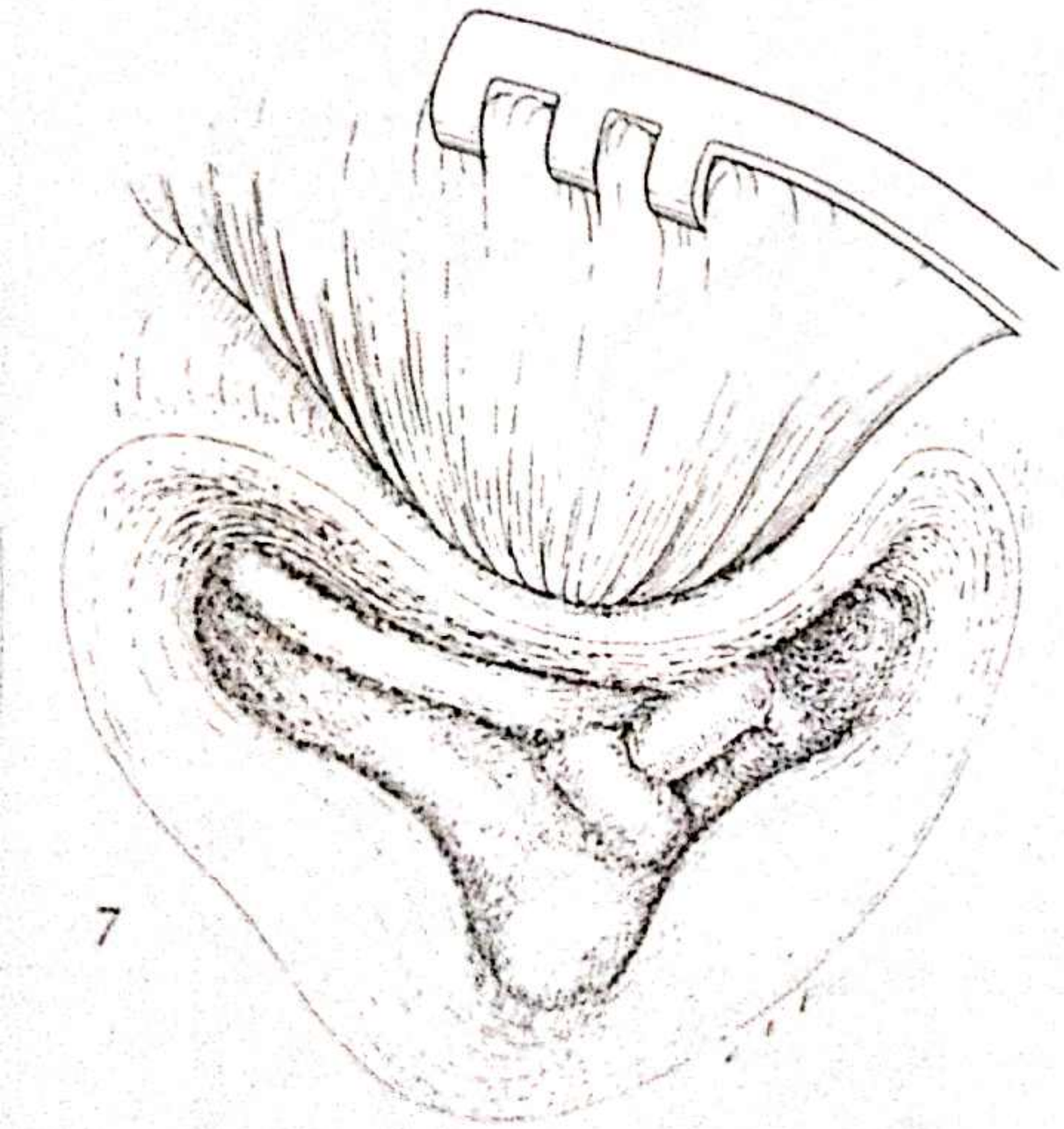
Approach to mastoid

6

The mastoid bone work is now commenced, using a large cutting burr and continuous irrigation. To save operating time, the initial work is done quickly with the head mirror and without using the microscope. This allows the surgeon to see the whole field and quickly uncover the sigmoid plate, the temporal and the cerebellar dural plates, and to locate the antrum and horizontal semicircular canal. The posterior canal wall can be taken down close to the bridge with rongeurs. The canal skin is cut transversely above the annulus, and a retractor with one long blade is used to displace the skin towards the anterior wall to protect it.



6



7

Excavation of mastoid

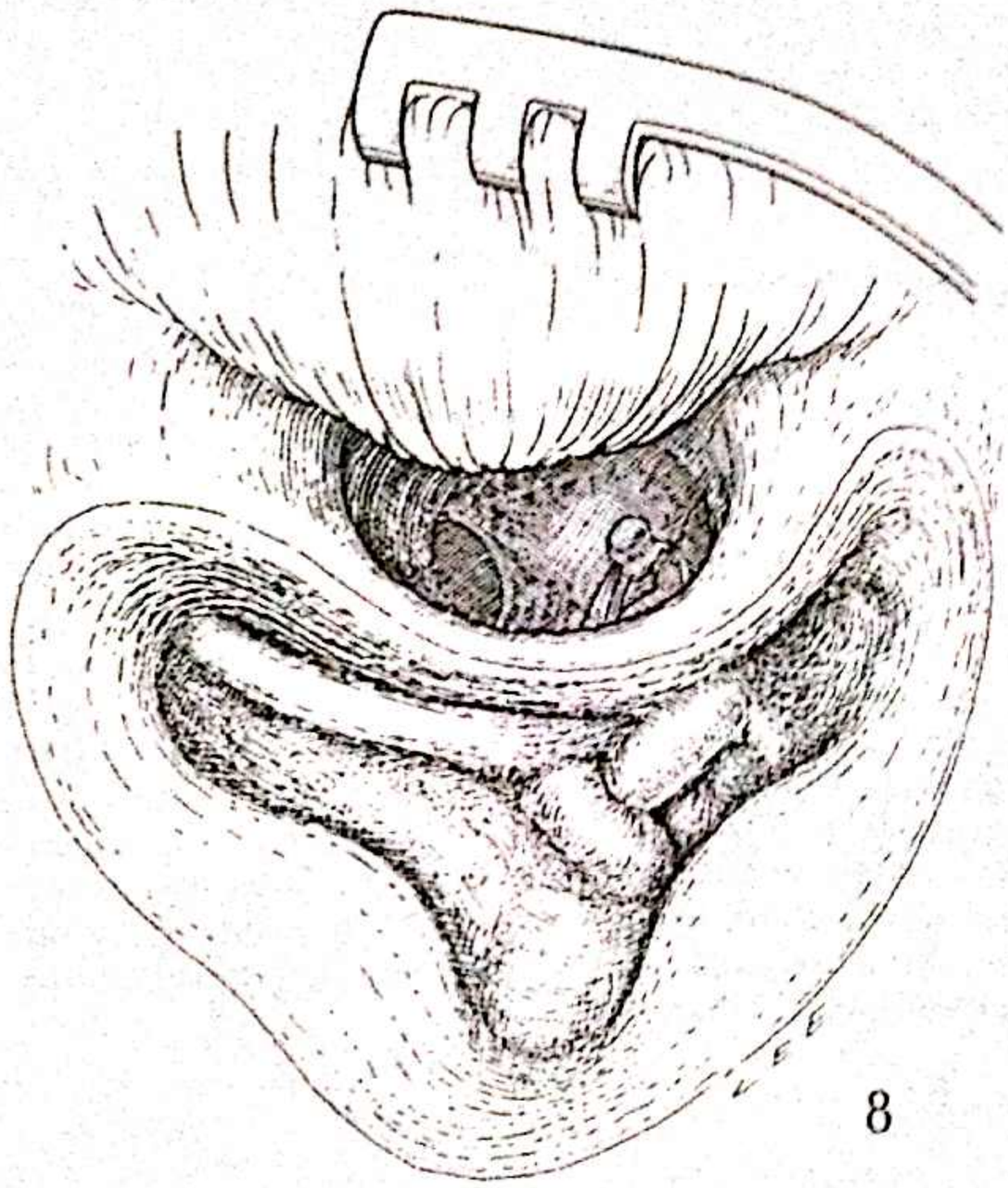
7

The microscope is used from now on. Under small magnification, all diseased tissue is removed from the mastoid tip. If necessary, the bony canal of the facial nerve is exposed and the retrofacial cell tracks are removed. Using the horizontal semicircular canal as a landmark, the surfaces of the posterior and superior canals are identified and Trautmann's triangle is cleared. In this area and around the canals it may be necessary to increase the magnification, and very small curettes and diamond drills must be used in exenterating all diseased bone and cholesteatomatous epithelium.

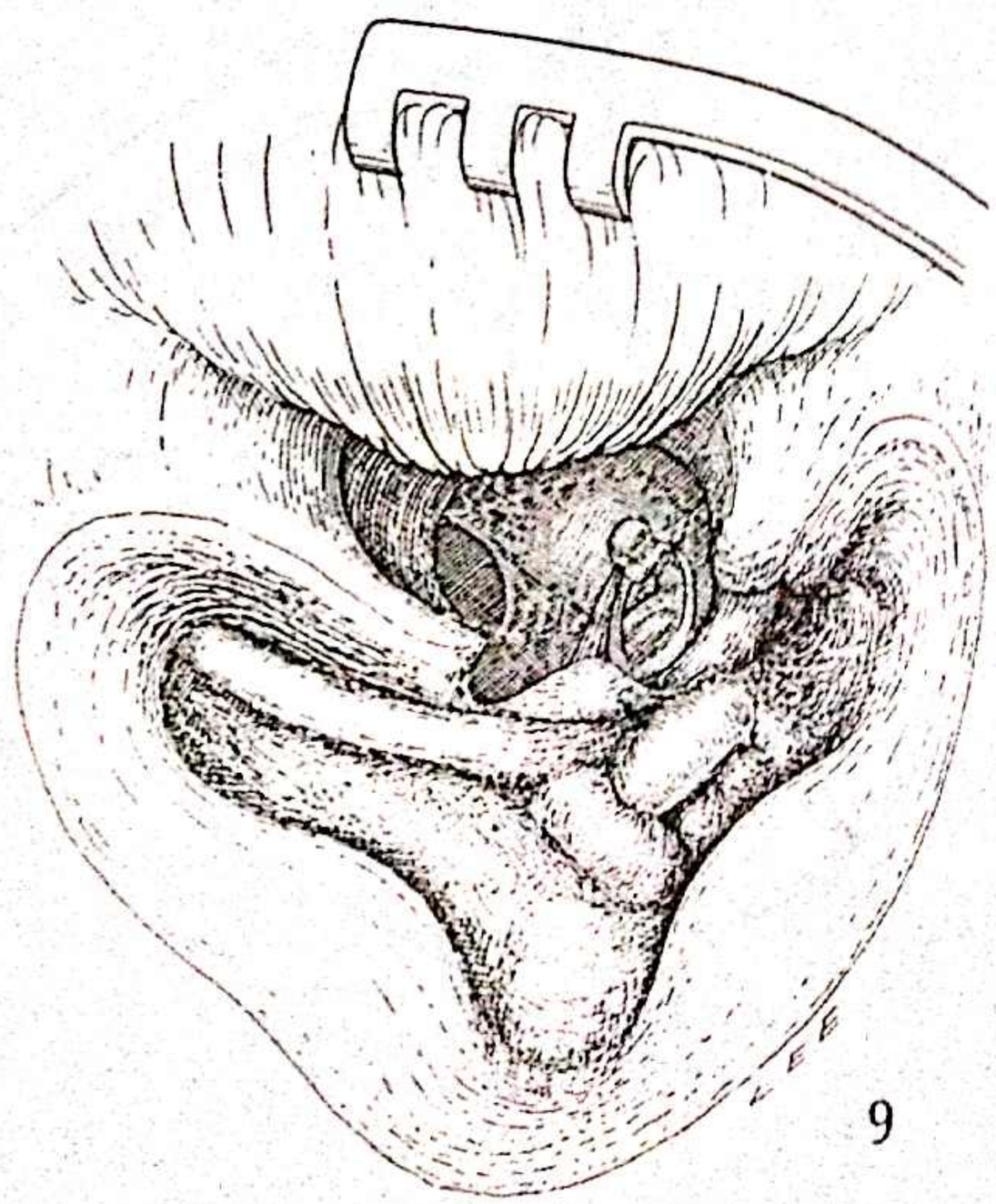
Removal of bridge

8 & 9

The remaining medial ear canal skin is lifted *en bloc* with the annulus and tympanic membrane (or drumhead remnants), cut along the midline to make the annular swing doors and dissected anteriorly. Sharp curettes are used to remove enough of the bone at the annulus to provide good exposure. If the incudostapedial joint is intact and cholesteatoma involves the ossicular area, the joint is opened and the incus pushed towards the antrum. The bridge is then removed with a cutting drill, the first breakthrough being made close to the malleus head to minimize the risk of damaging the stapes. The lower part of the bridge is removed either with a drill or with large curettes. When a large burr is used anywhere around the area of the stapes, care must be taken that its distant edge does not touch the stapes by accident.



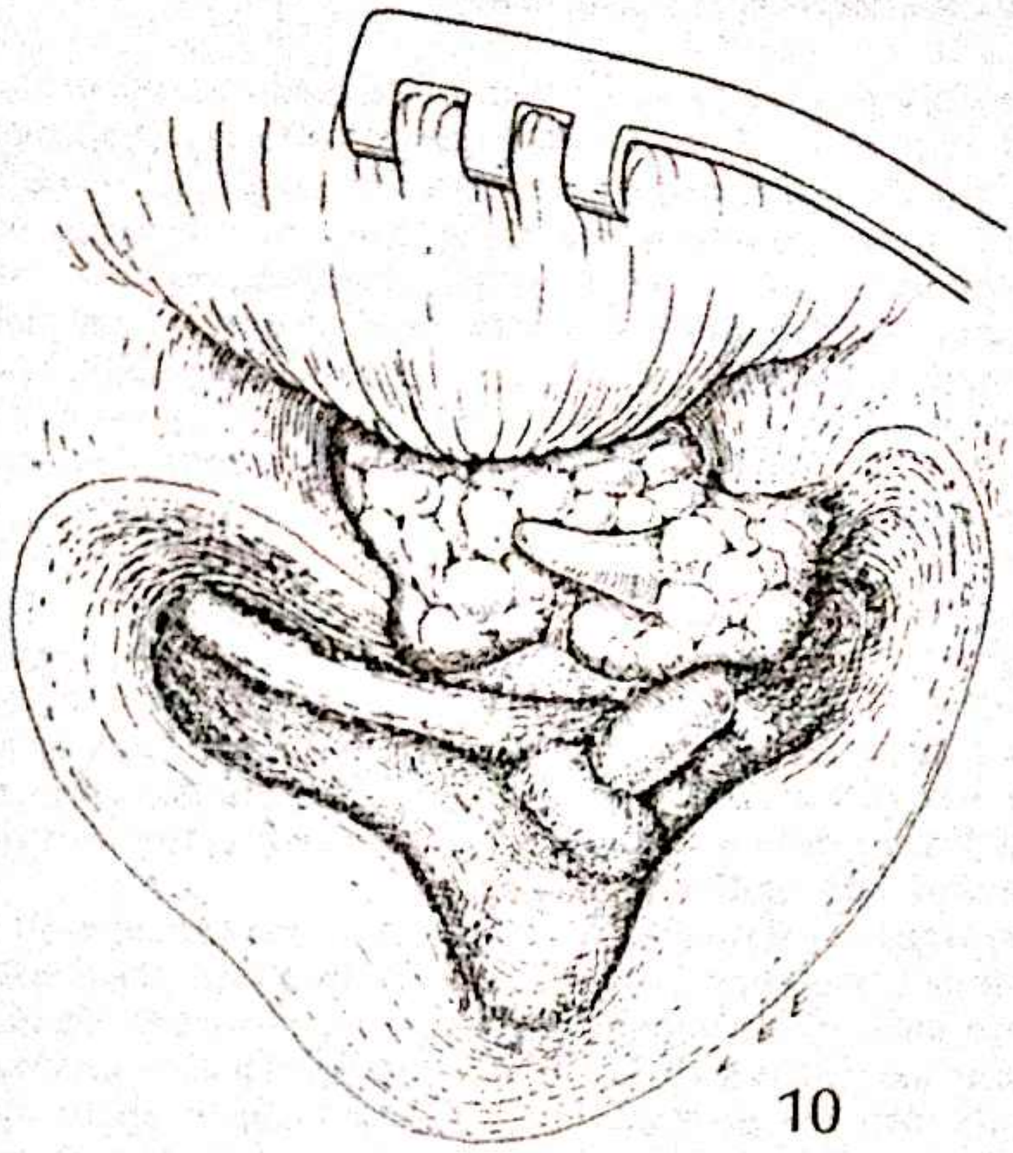
8



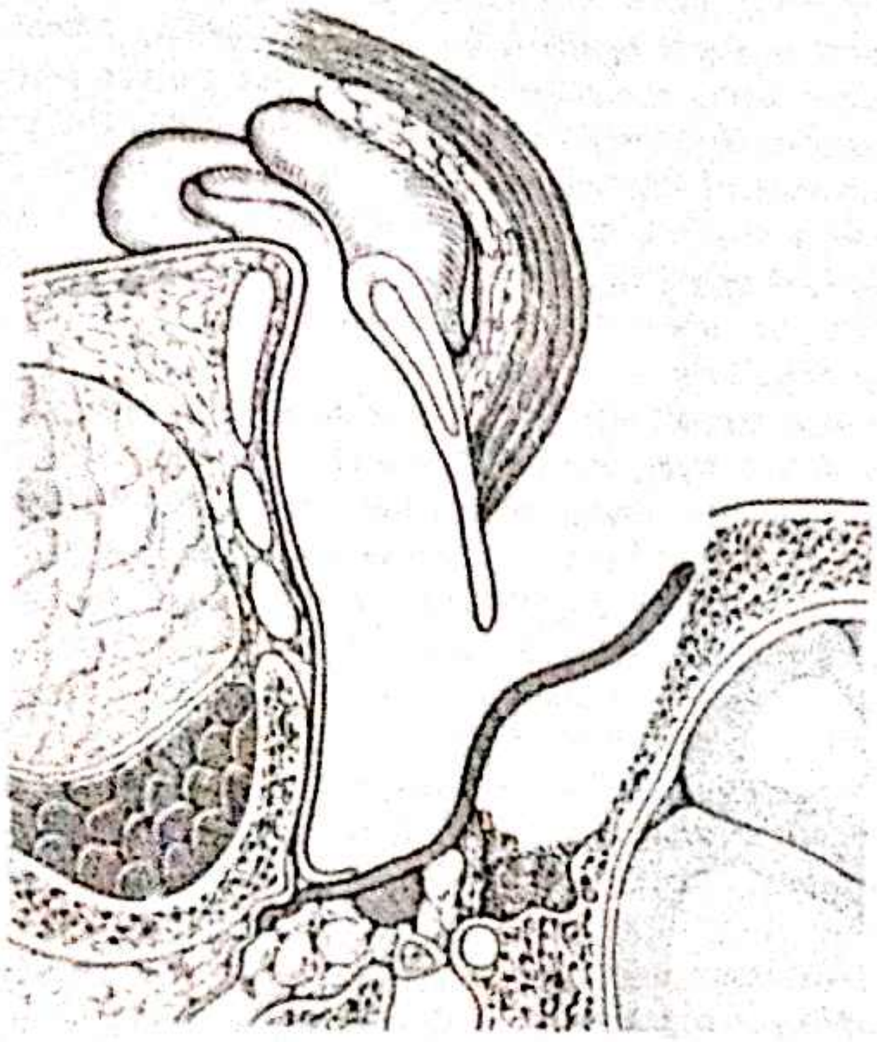
9

10

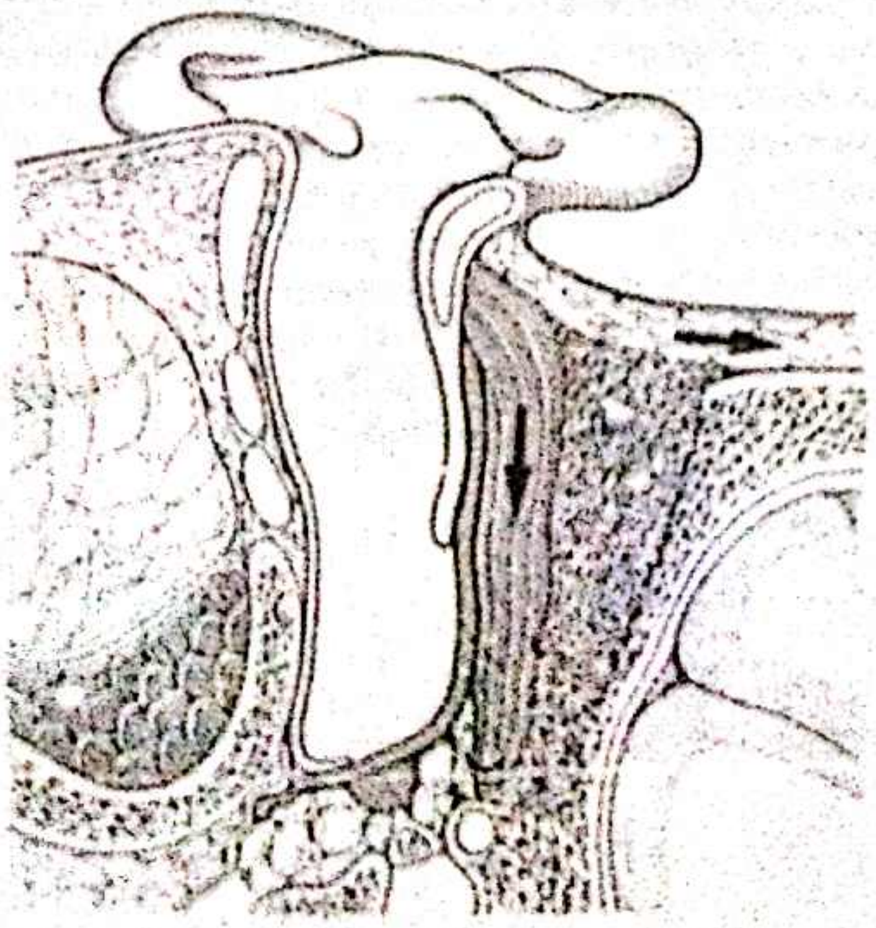
Both the lower and upper buttresses of bone are removed with a large cutting drill to make the edges of bone flush with the inferior tympanic membrane margin and the superior portion of Shrapnell's membrane. The head of the malleus is removed and all remnants of cholesteatoma are cleared from the epitympanic space, the area of the superior canal ampulla and the geniculate ganglion. As a final step, these areas are polished with a diamond drill to make sure that only healthy, lamellar or capsular white bone remains. Diseased mucosa is then removed from the middle ear cleft itself. Wide safety margins should be allowed, bearing in mind that the advancing front of squamous epithelium may be quite distant from the gross extension of the keratin accumulation of the cholesteatoma proper.



10



11



12

Middle ear reconstruction related to obliteration

11 & 12

Basically two types of ossicular reconstruction are used: building either on an intact stapes head or starting from the footplate itself. An ossicle homograft or cortical bone is used to ensure maximum tolerance. If the stapes is healthy, a pipe-type columella is used, the bowl sitting snugly at the stapes head and the shaft projecting towards the area of the umbo. The shaft is made short if most of the pars tensa is present and longer if most of it is absent. For reconstruction from the footplate, either an intact incus or an L-shaped cortical bone columella is used, one end lying in broad contact with the footplate and the other on a piece of lyophilized dura (or Silastic sheeting) in the anterior part of the tympanic cavity. Its highest, most lateral part should be flush with the original level of the tympanic membrane. Pieces of Gelfoam soaked in adrenaline are inserted around the ossicles and the middle ear is filled with Gelfoam pieces to ensure good stability. The anterior part of the semi-dry fascial graft is then placed over the Gelfoam, and the ossicles and fascial margins are adjusted medial to the tympanic membrane remnants. The superior and inferior swing door flaps of annular skin are repositioned on top of the fascia, and one or two round cigarette-paper patches soaked in 0.5 per cent gentian violet are applied to cover the whole reconstructed tympanic membrane. Small rolls of gauze impregnated with gentamicin are placed side by side on top of the tympanic membrane in three layers. The tympanic reconstruction is now completely stable.

Reconstruction of canal wall

The retractors are released and, while the musculoperiosteal flap is held in the left hand with forceps, two gentamicin-gauze strips are inserted through the meatus, the first one touching the gauze rolls on the tympanic membrane. These gauze strips effectively widen the meatus to the desired width, and the skin can be smoothed along the tamponade which is well visible. The large remaining part of the fascia is then lifted up from the mastoid cavity and smoothed along the posterior meatal skin. The fascial lining should reach the lateral bone level. Bone chips with the periosteum towards the ear canal are then inserted into the epitympanum, filling it from the region anterior to the geniculate ganglion up to the lateral bone level. To increase the height of the tympanic cavity, bone chips (or strips of lyophilized dura) are applied to the area of the facial nerve canal. This is the last stage at which the position of the ossicular reconstruction can be checked and readjusted if necessary.

In large cavities, the soft ear canal is reinforced with a layer of bone chips, which are cemented into place with bone paté. At this stage, or before the tympanic fascial reconstruction is started, most of the bone paté is pressed firmly into the postlabyrinthine area to fili it up to the anterior wall of the sigmoid sinus. It is important to press the bone paté dry within a piece of gauze to facilitate the cementing process. The musculoperiosteal flap is then turned into the cavity, taking care that its tip reaches the bone of the superior canal ampulla.

Small and medium-sized cavities are well obliterated with the flap. If the cavity is large, there may still be some space to be filled. This is done with any leftover bone paté and bone chips are used, and Braun inorganic bone grains (B. Braun, Melsungen, W. Germany) are then used to fill the remaining space. Care should be taken to place them only in the bony cavity and not disperse them into the soft tissues where they cause temporary irritation because of their sharp edges.

I prefer to use very thin sheets of lyophilized dura to cover raw surfaces in the tympanum, and full-thickness dural pieces to increase the tympanic height and to reinforce the soft ear canal wall. Since this adds somewhat to the cost, not all surgeons may elect to use lyophilized dura but it is a very versatile material and well accepted by the body.

The skin is sutured with non-absorbable material, first with three mattress sutures and then with sutures to approximate the wound edges. A drain is inserted, and two gauze strips are placed in the ear canal and an appropriate head bandage applied.

Postoperative care

Antibiotic treatment is continued until the patient is discharged from hospital. The bandage is removed on the first postoperative day and suction is applied to the drain. A light bandage can now be used and the drain is removed on the second day after surgery. The superficial gauze strip in the ear canal is changed daily. Before inserting the new strip, 1–2 drops of gentian violet should be applied to its tip. Serum which may accumulate behind the ear if postauricular bleeding occurs is sucked out daily. The sucker can safely be introduced 2–3 cm into the subcutaneous space to suck out all fluid. The posterior skin heals well in 5 days, when the superficial stitches can be removed. On the 6th or 7th day, the last stitches are removed, after which the gauze strips and gauze rolls are removed from the ear canal under microscopic control. The cigarette paper patches should not be removed, since they still effectively stabilize the tympanic membrane. If the ear canal is of normal size, it is filled with gentamicin Vaseline, applied with a 2 ml syringe and a disposable, sufficiently large-bore suction tip. The patient is discharged and is seen again after 3 to 4 weeks, when the Vaseline remains are sucked out and the paper patches removed under microscopic control. The tympanic membrane and most of the ear canal are now well healed and require only a touch of gentian violet. The patient must be warned against using cotton earplugs in the canal and told to keep the ear open and to continue with the Valsalva procedure regularly.

Should the canal show a tendency towards distinct narrowing when the tamponade is taken out, two pieces of Otowick or one Merocel tampon is placed in the ear canal and expanded with gentian violet drops. The tampons, surrounded by gentamycin Vaseline, are kept in the ear for 1 additional week, when they are removed and postoperative care is continued as described above. All ears operated on for cholesteatoma are examined at 3 and 6 months postoperatively and then once a year for 5 years. Thereafter, asymptomatic ears are no longer inspected at regular intervals but the patients are told to come for a consultation if any problem arises. Ears in which spontaneous wax transport is deficient, should be checked once a year.

If significant cavitation occurs and the entrance to the meatus is narrow, wide meatoplasty should be carried out under local anaesthesia. This effectively prevents difficulties in canal skin wax transport.

A surgeon inexperienced in obliteration surgery can start by deliberately creating a small cavity and carrying out a semi-obliteration. A wide endaural meatoplasty is done and the large musculoperiosteal flap is used to fill the posterior part of the cavity. As experience increases, the surgeon learns to make use of the other advantages of the obliteration method described above.

Illustrations by Gillian Lee

Surgery of the facial nerve (tympanic portion)

John Groves MB, BS, FRCS
Consultant Surgeon, Ear, Nose and Throat Department, Royal Free Hospital, London, UK

This section is concerned only with the intratemporal, infrageniculate course of the nerve. (For operations in the internal meatus see chapter on 'The middle fossa approach to the internal auditory meatus', pp. 204–218.)

Preoperative

Indications

Either post-traumatic or 'otogenic' facial nerve lesions may require decompression or repair by nerve grafting.

In palsies due to trauma, only the minority with complete palsy of immediate onset and total absence of motor-unit potentials on electromyography require surgery. Every facial palsy due to cholesteatoma or neoplasm (e.g. facial nerve neurofibroma) must be treated as soon as recognized.

Bell's (idiopathic) palsy is not an indication for decompression of the nerve.

Anaesthesia

The patient should be suitably prepared for hypotensive anaesthesia, although this is not always required.

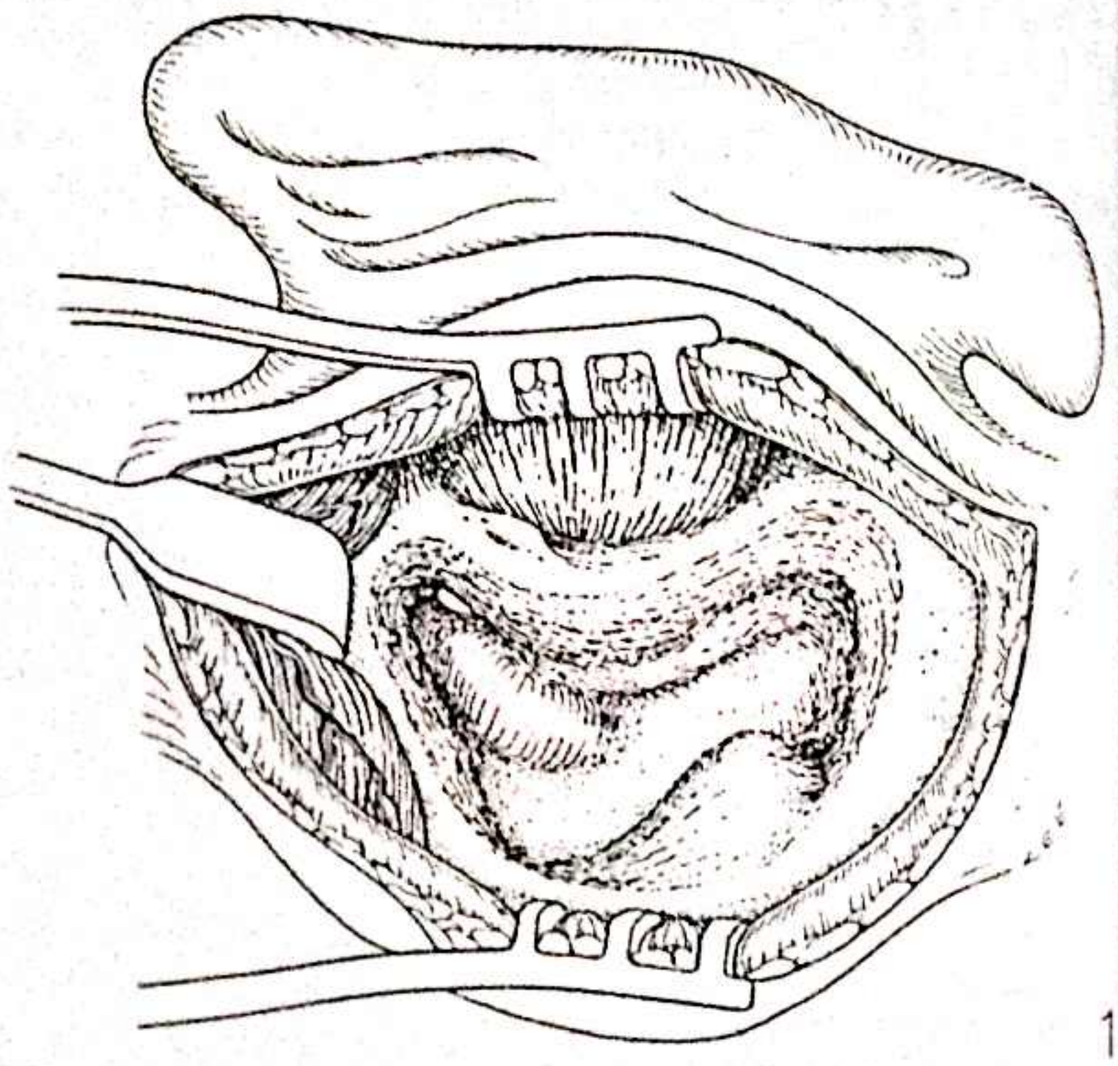
Approach

Limited access, which may be adequate in some cases, can be gained by an 'endaural' approach, or even by permeatal tympanotomy. Only the transmastoid (postaural) approach, proceeding to posterior tympanotomy, can be guaranteed to meet all eventualities and anatomical variations. Preoperative radiographs, even when not helpful in defining the disease or lesion, still give useful foreknowledge of the individual anatomy.

The operation

The incision

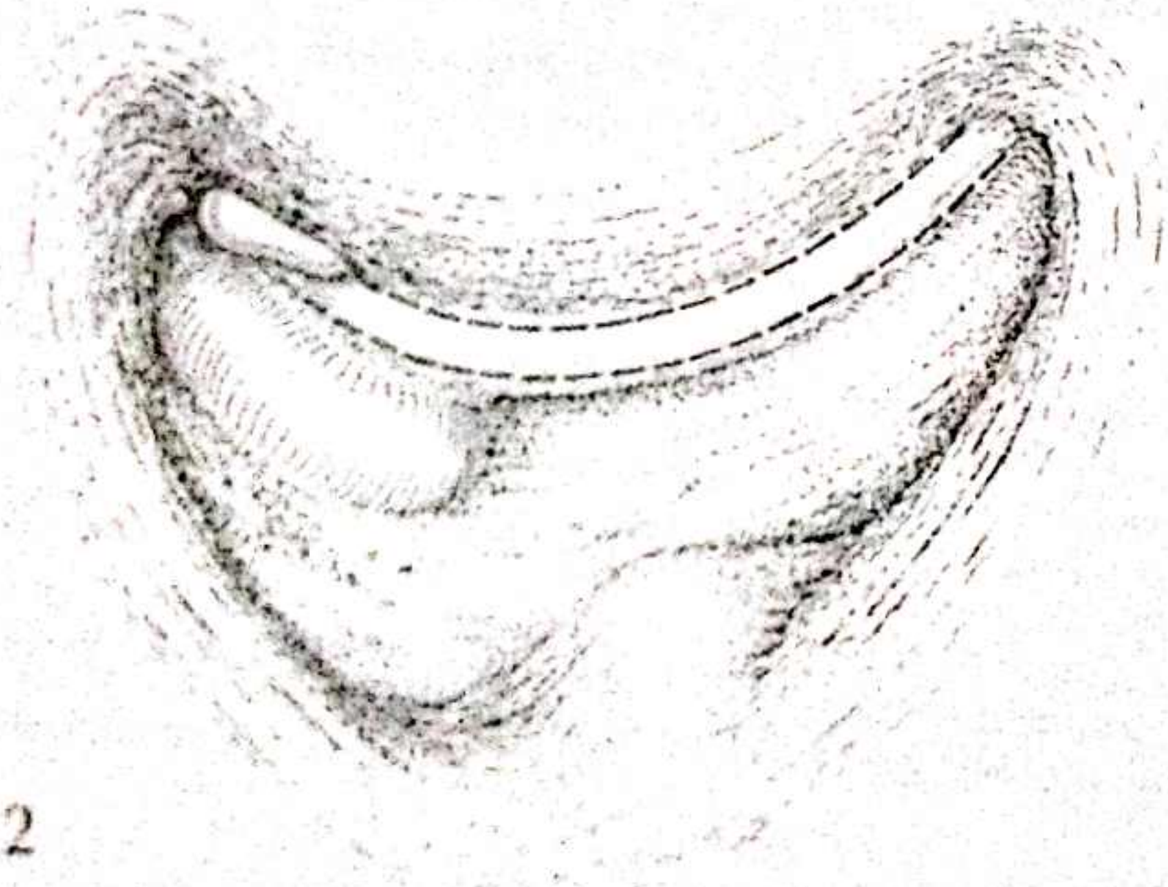
After infiltration of the soft tissues with 0.5 per cent lignocaine (lidocaine) and adrenaline 1:200 000 a standard postaural incision is made. The temporal muscle is freed with a periosteal elevator and retracted upwards to expose the posterior root of zygoma and suprameatal triangle. The mastoid process is cleaned down to its tip, but it is unnecessary to strip its inferior or medial aspects. Do not separate the meatal skin from the bony canal unless it has already been decided that a radical 'mastoidectomy' is inevitable.



1

Mastoid clearance

With a large cutting burr the mastoid cortex and air cells are removed to open the antrum and aditus, and to expose clearly the bony lateral semicircular canal, posterior aspect of incus, tegmen tympani, lateral sinus plate and digastric ridge.



2

Location of the nerve

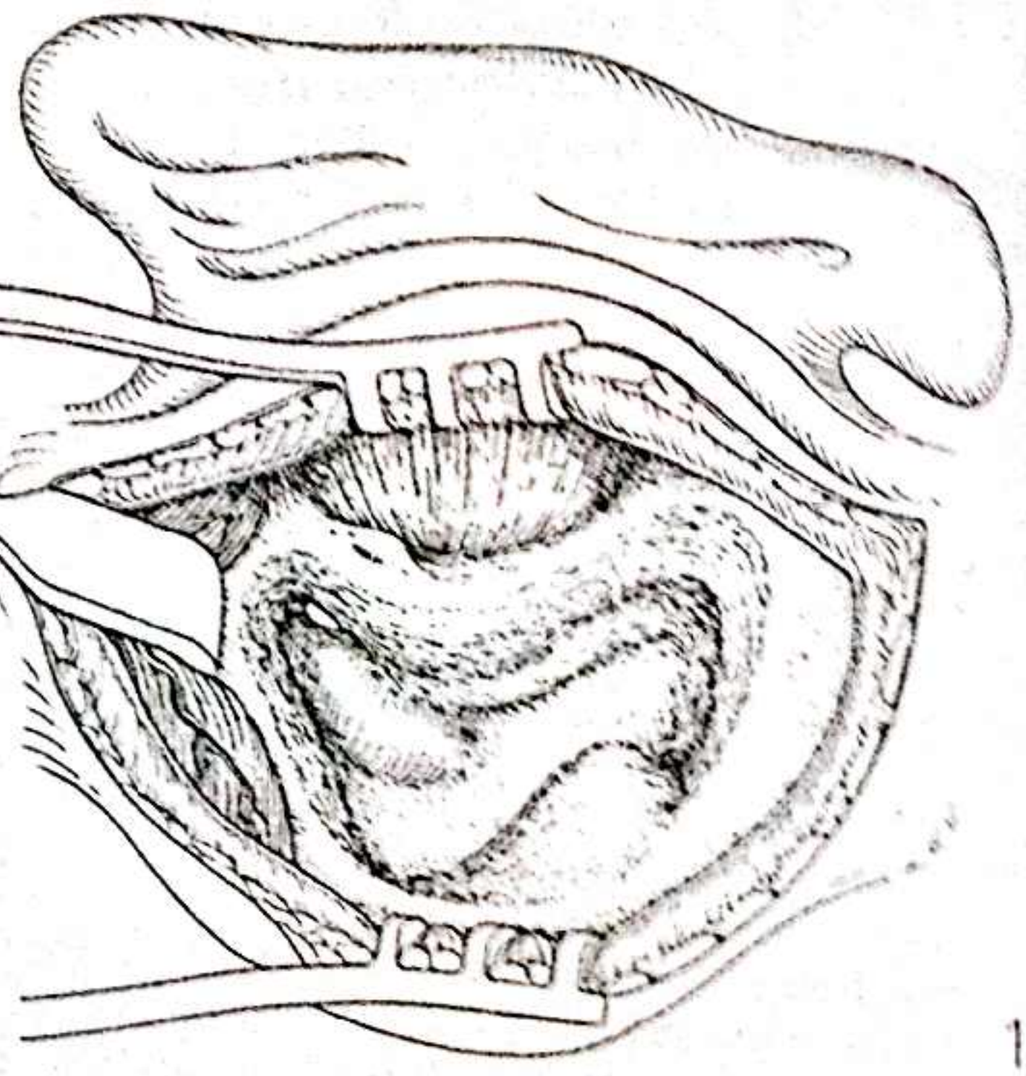
As the posterior tympanotomy is developed under magnification, and with finer burrs (ultimately diamond paste), the position of the nerve immediately below the lateral semicircular canal may be inferred with some accuracy, even if it is not obvious, as a backward and downward continuation of the line of the horizontal portion. The latter is visible in the gap between the short process of incus laterally and the lateral canal medially.

Disease, or previous surgery, may obscure these relationships.

The operation

The incision

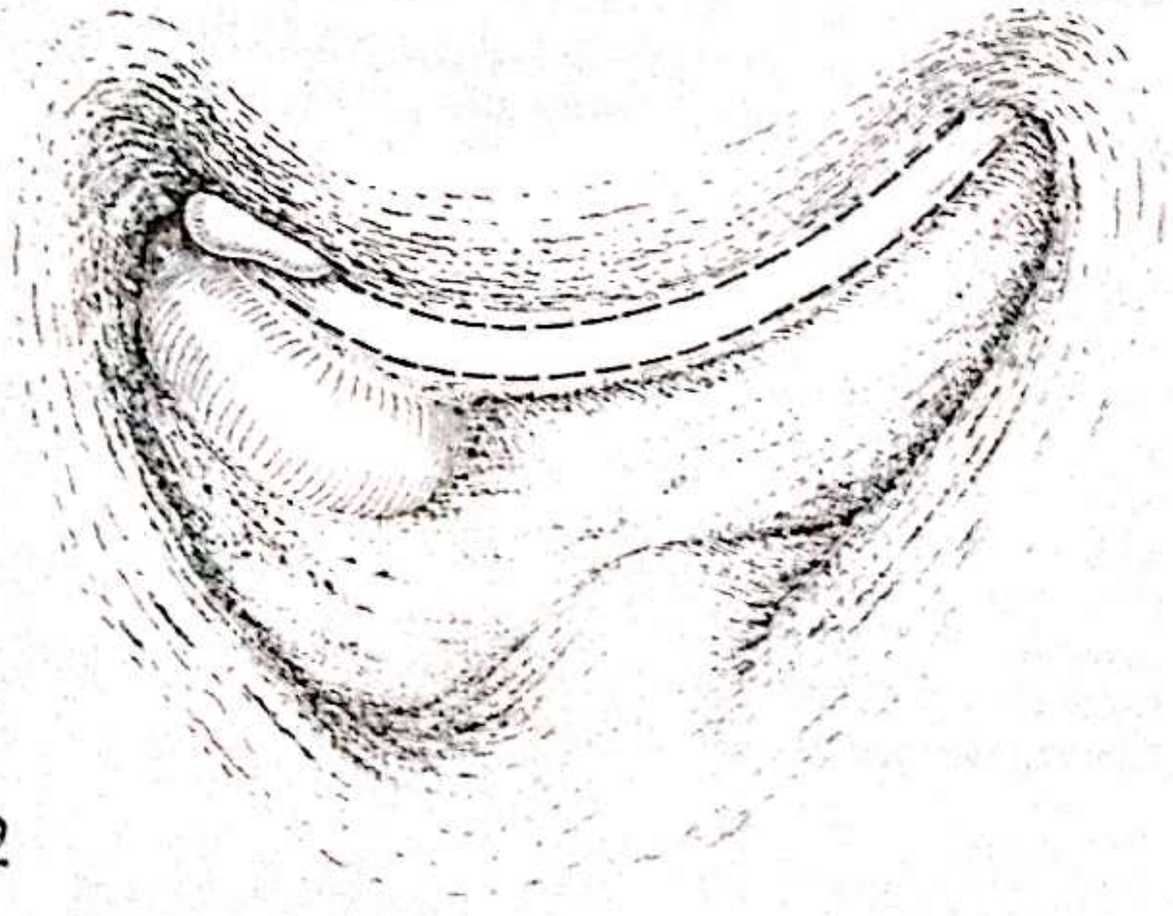
After infiltration of the soft tissues with 0.5 per cent lignocaine (lidocaine) and adrenaline 1:200000 a standard postaural incision is made. The temporal muscle is freed with a periosteal elevator and retracted upwards to expose the posterior root of zygoma and suprameatal triangle. The mastoid process is cleaned down to its tip, but it is unnecessary to strip its inferior or medial aspects. Do not separate the meatal skin from the bony canal unless it has already been decided that a radical 'mastoidectomy' is inevitable.



1

Mastoid clearance

With a large cutting burr the mastoid cortex and air cells are removed to open the antrum and aditus, and to expose clearly the bony lateral semicircular canal, posterior aspect of incus, tegmen tympani, lateral sinus plate and digastric ridge.



2

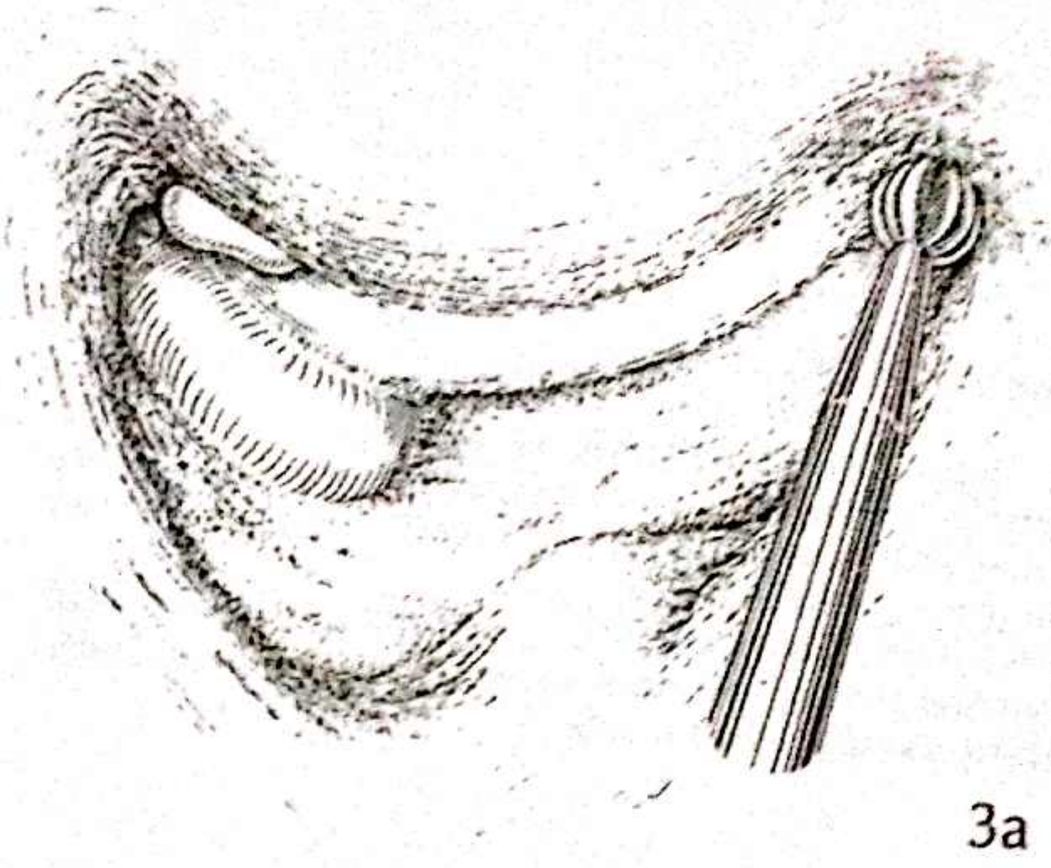
Location of the nerve

As the posterior tympanotomy is developed under magnification, and with finer burrs (ultimately diamond paste), the position of the nerve immediately below the lateral semicircular canal may be inferred with some accuracy, even if it is not obvious, as a backward and downward continuation of the line of the horizontal portion. The latter is visible in the gap between the short process of incus laterally and the lateral canal medially.

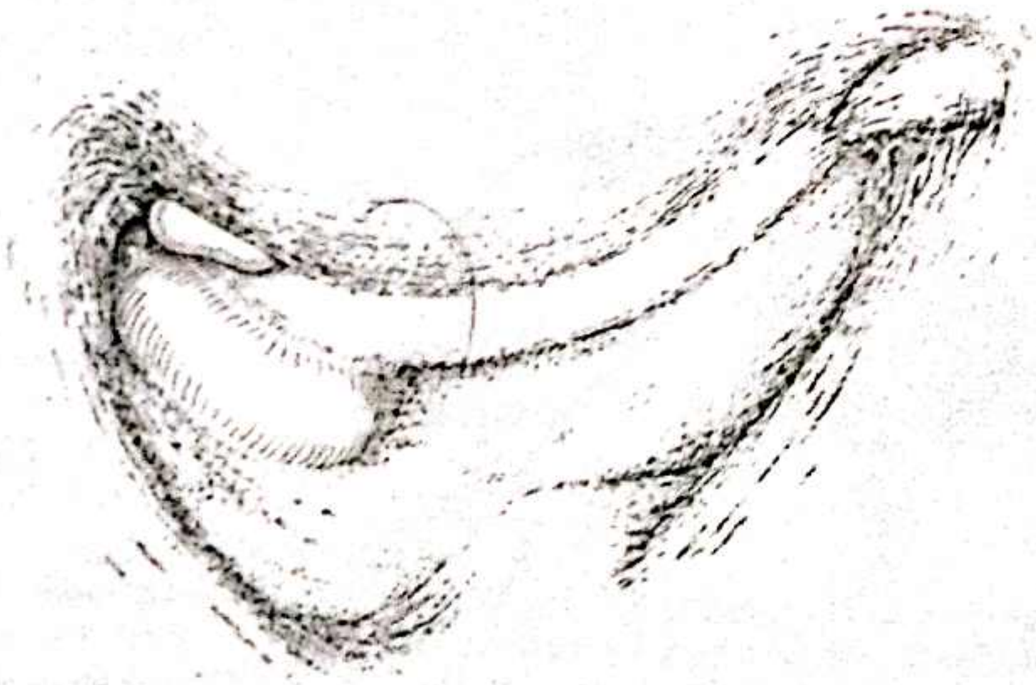
Disease, or previous surgery, may obscure these relationships.

3a & b

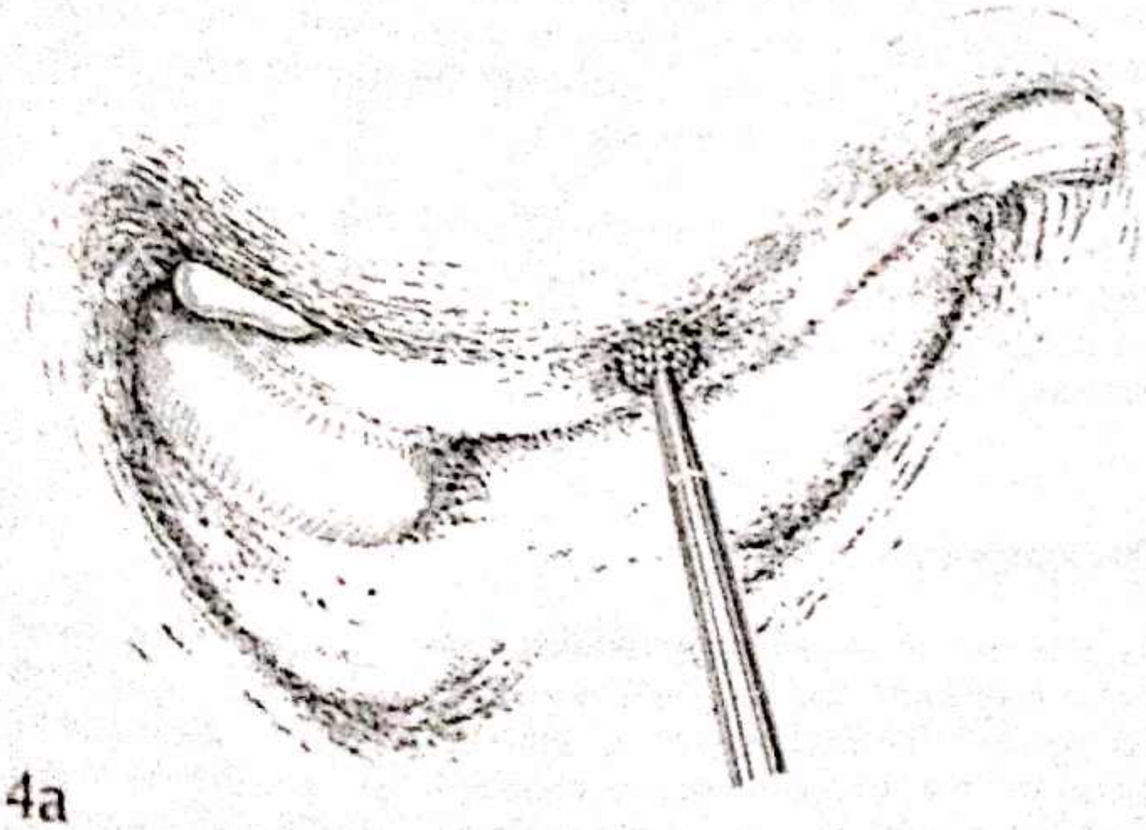
At the stylomastoid foramen the nerve is found by patient drilling at the anterior end of the digastric ridge. If the latter is poorly defined (in an acellular bone) it is necessary to drill well forward of the sinus plate, and in a plane lower than the meatal floor, until the periosteum on the medial surface of the mastoid process is reached. This is followed medially and upwards until it is defined as converging, funnel-wise, into the foramen.



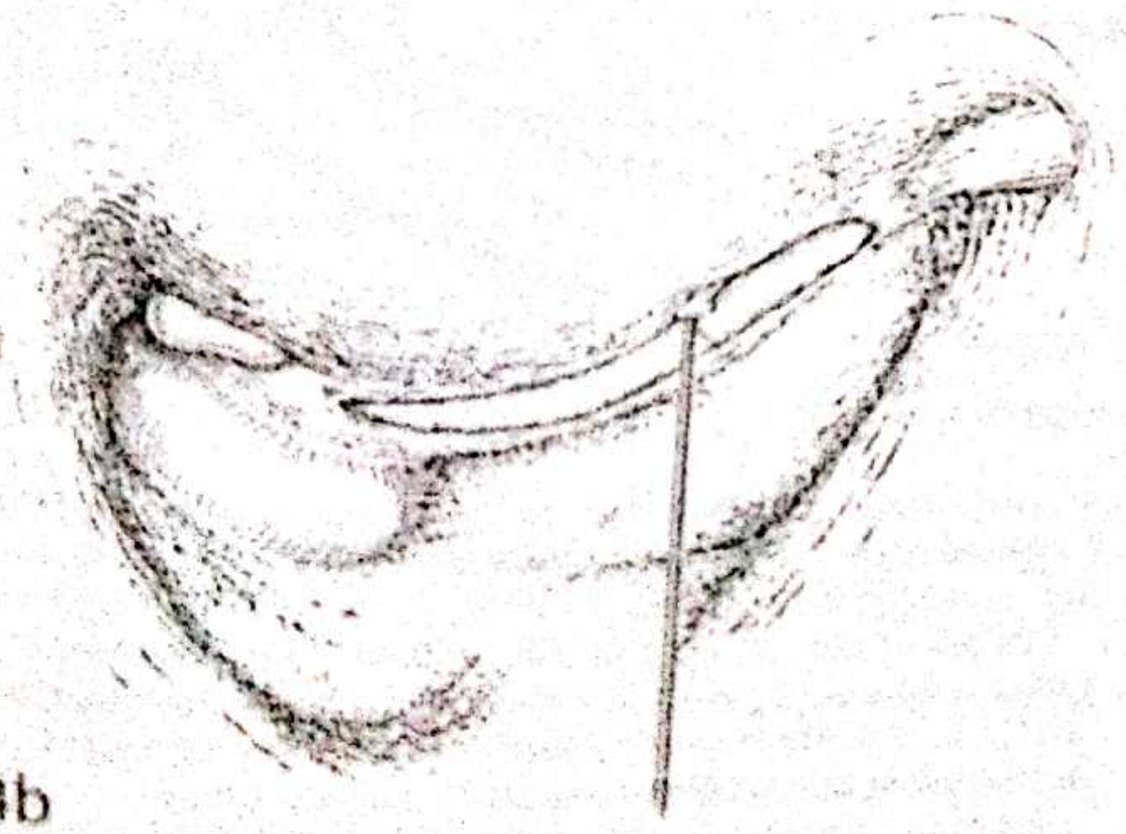
3a



3b



4a



4b

4a & b

Exposure of the nerve

Whether first located from above or below (ideally from both directions), the Fallopian canal is skeletonized throughout its length with a diamond drill (*a*). The tool must be stroked parallel to the nerve and without pressure. Constant irrigation with Ringer-Locke solution for cooling is essential.

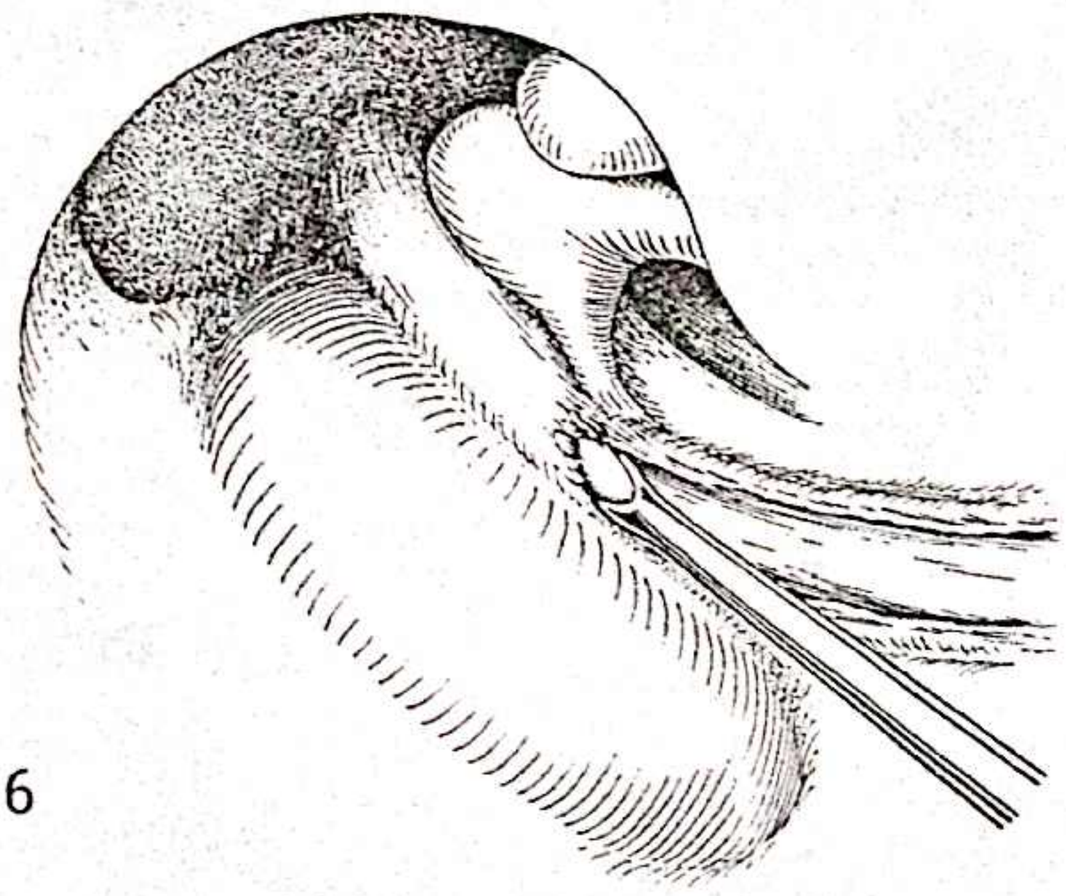
The nerve sheath is finally uncapped with extra-fine hooks and fenestration curettes (*b*).

5

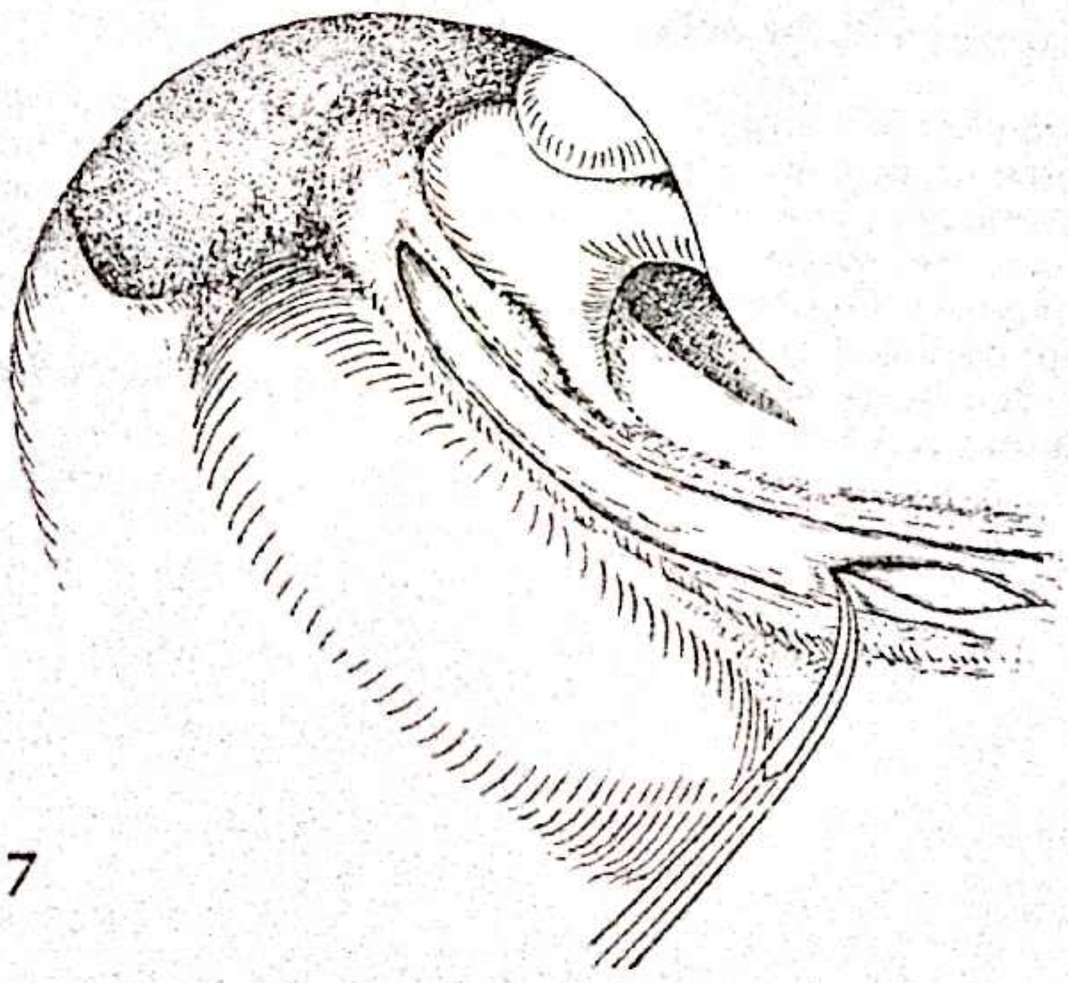
Anatomical complexities

The chorda tympani arises at a variable level, and wherever found may cause confusion. It is, of course, smaller and, except at its point of origin, more superficial than the main trunk.

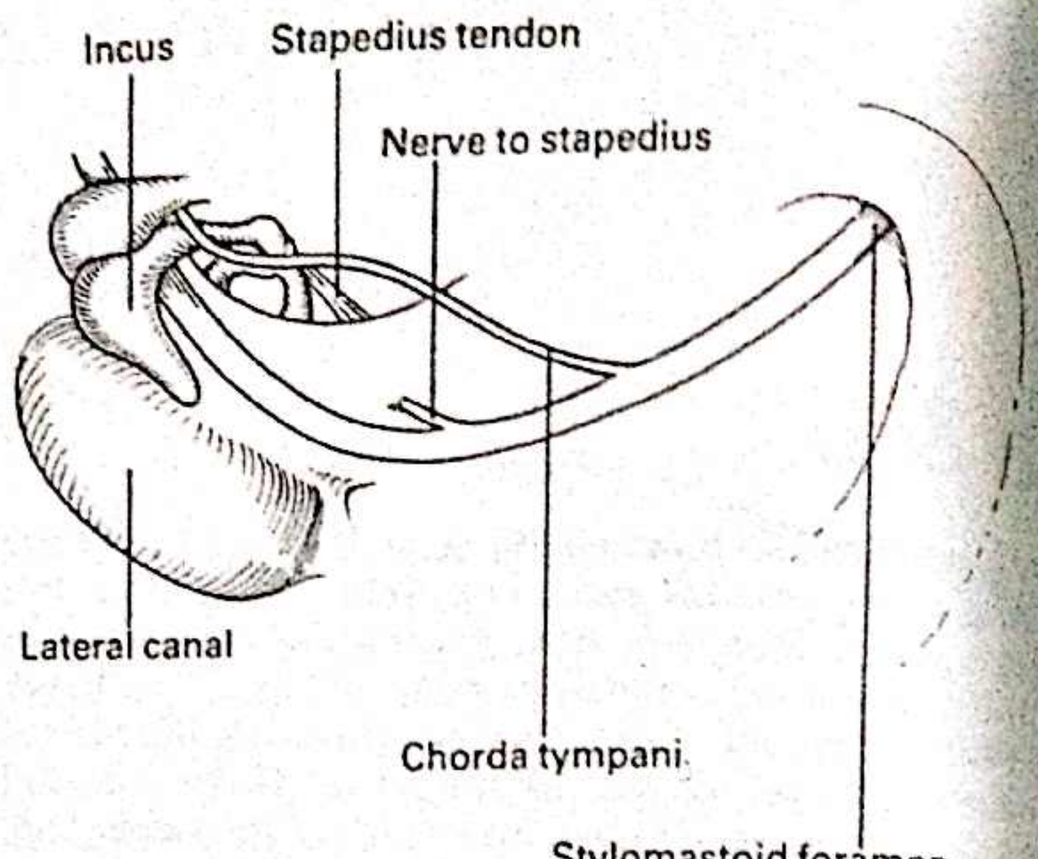
The branch to stapedius goes forwards from the pyramidal part of the facial nerve, and if followed leads into the canal for the muscle.



6



7



5

6

Tympanic part of nerve

This can be followed forwards with very fine picks and forceps from the pyramidal segment. Usually, the bony cover here is so thin that no drilling is necessary. If the anatomy is favourable the geniculate ganglion may be approached but, as the angles close in, a point is reached at which nerve exposure can only be continued if the incus is displaced or removed.

The preoperative hearing level and the nature of the lesion requiring surgery must decide whether surgical correction of any ossicular disruption is justifiable or necessary.

Decompression

As the nerve sheath is exposed, any compression by a bone fragment due to previous trauma or surgery will be recognized and relieved. Cholesteatoma or tumour is lifted off the exposed nerve trunk. If the sheath is intact and the nerve in obvious continuity no more need be done.

7

Opening the sheath

A very fine sickle knife is used to slit the sheath longitudinally, cutting upwards and outwards away from the nerve fibres within.

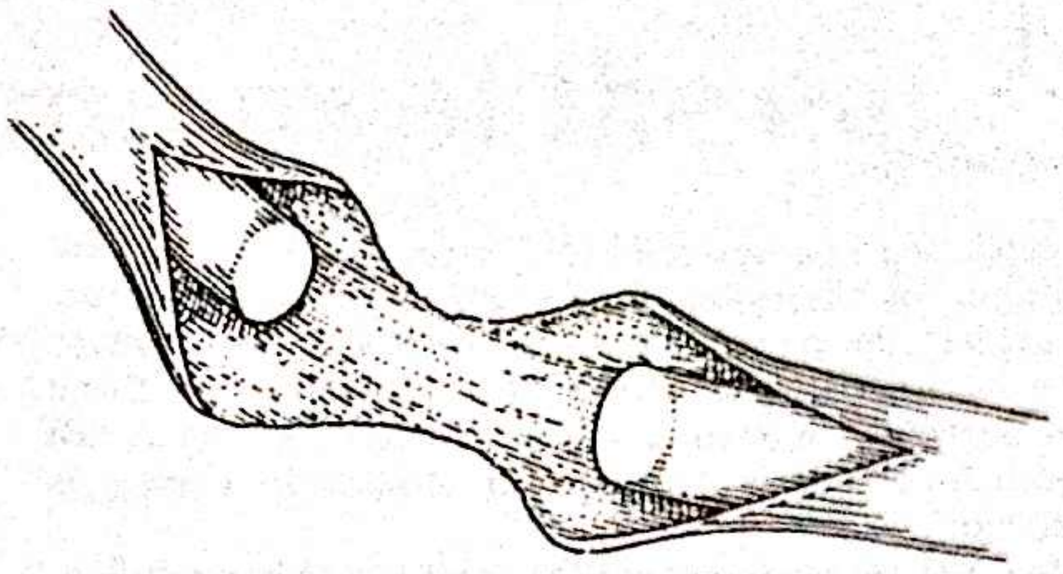
Unless there is reason to believe that the nerve is grossly disrupted, or that there may be fresh haemorrhage within it, it is often unnecessary to open the nerve sheath. In the presence of gross sepsis it may be unwise.

Opening the sheath is an essential preliminary if a dense 'neuromatous' scar is to be excised and a graft inserted.

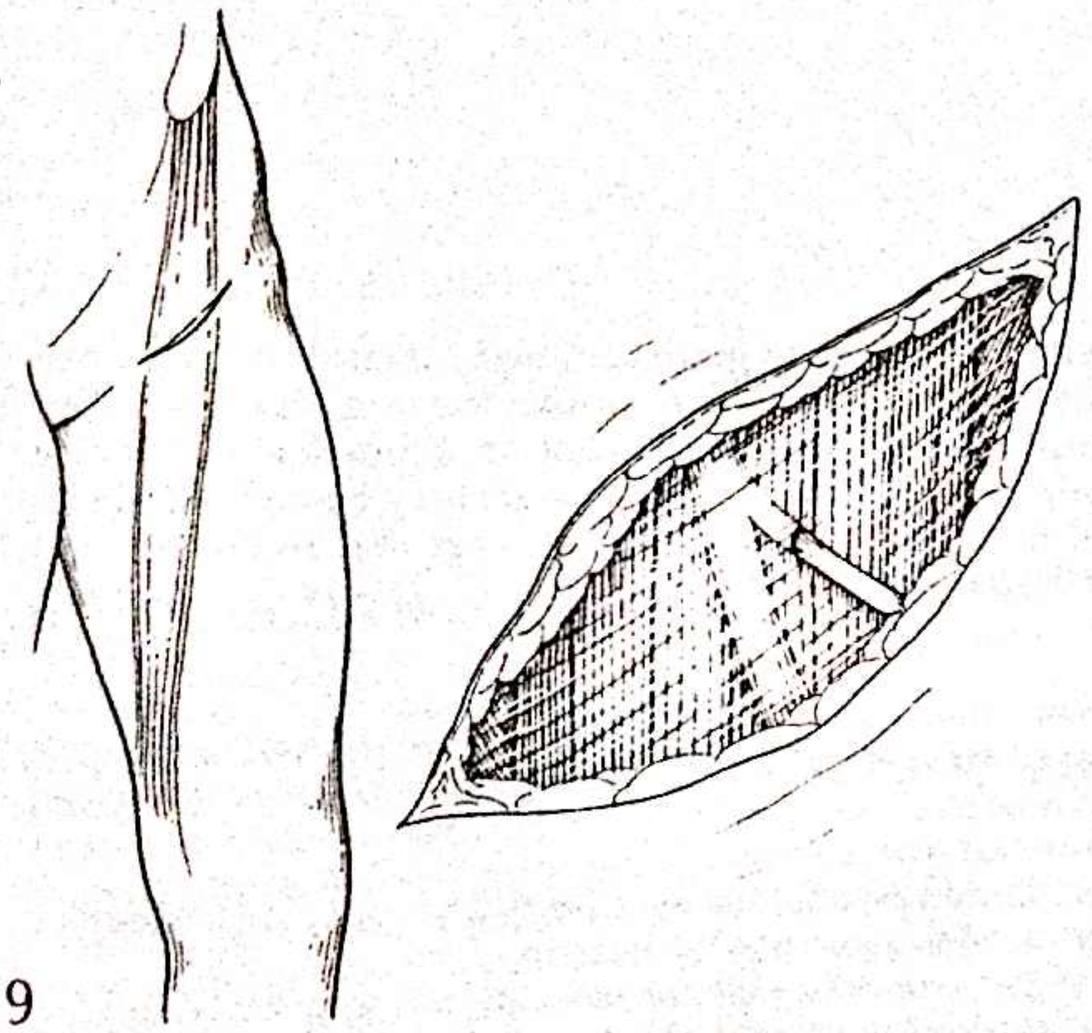
Intratemporal nerve graft

8

The lesion is clearly defined and excised. Proximal and distal nerve stumps must be cleanly and squarely cut across, well clear of scar tissue. The gap should not be less than 1 cm between the stumps.



8



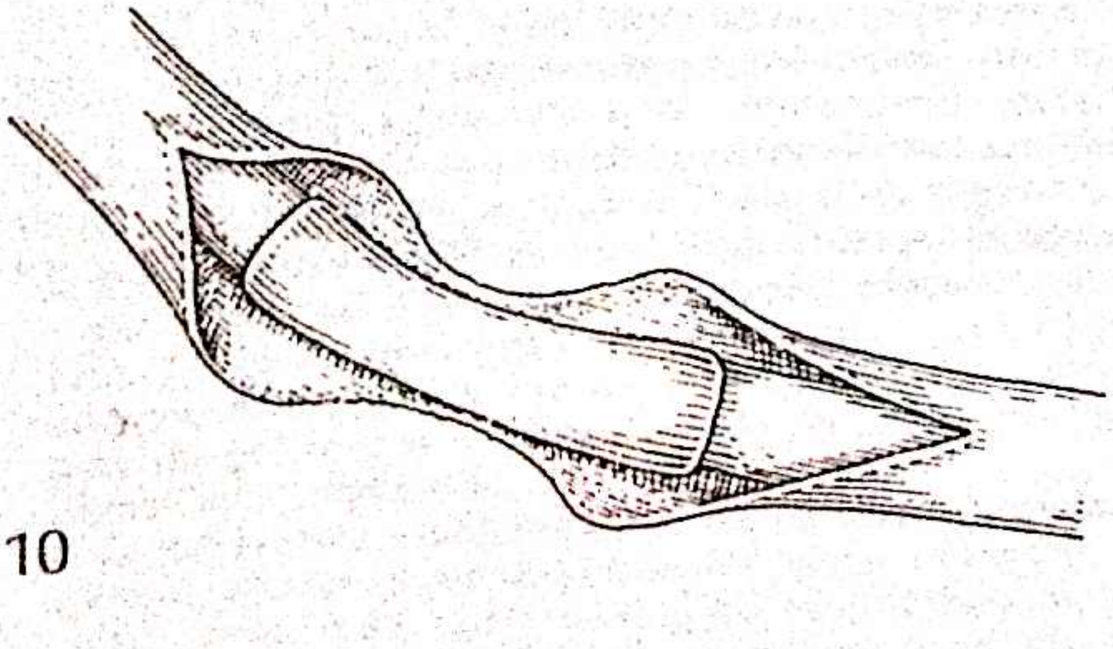
9

9 & 10

Donor nerve may be taken from the great auricular nerve or, preferably, the lateral cutaneous nerve of the thigh. It should be cut 1 or 2 mm longer than the gap in the facial nerve, and laid into the Fallopian canal. The cut ends are carefully adjusted for accurate apposition.

Stabilization of graft

Fresh fibrin is precipitated by dripping on to the repair, alternately from separate syringes, drop by drop, a solution of human fibrinogen and a solution of thrombin. The bony gutter provides enough stability to eliminate any need for sutures.



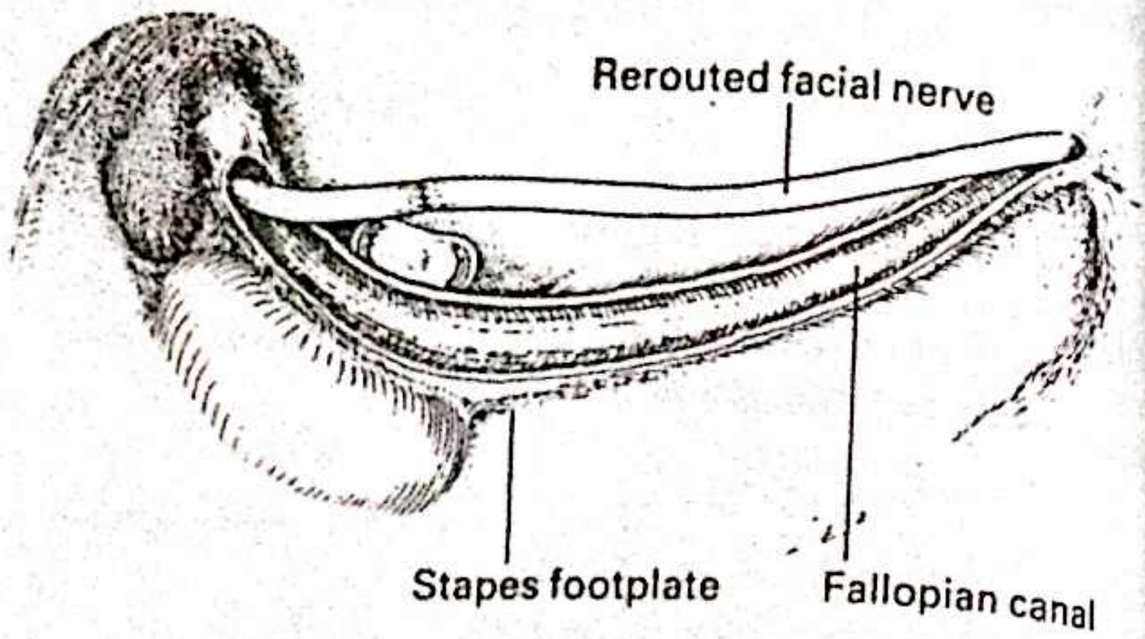
10

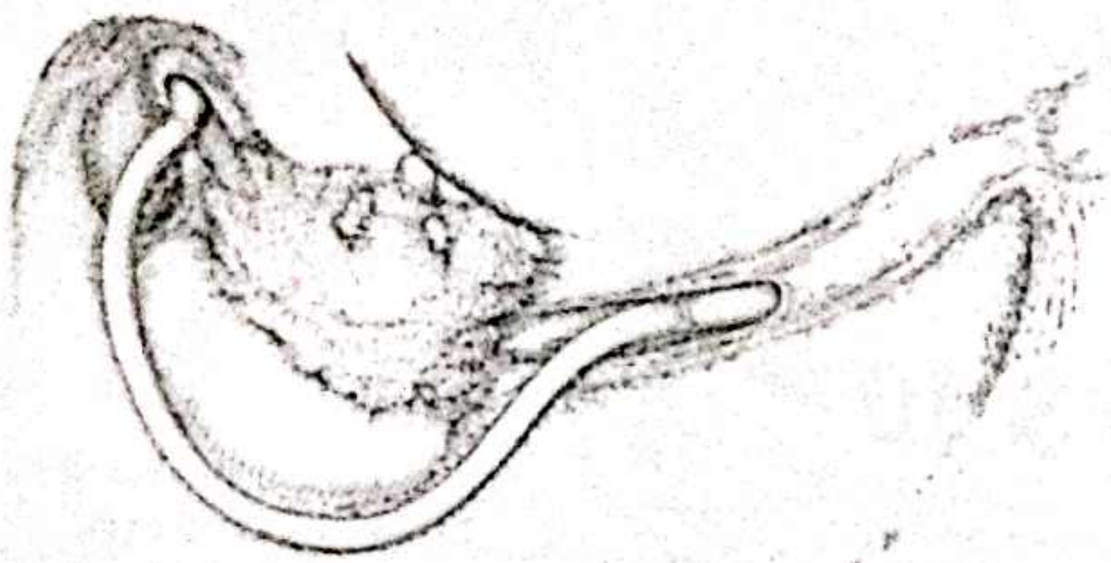
11

Re-routing

A small gap in a severed facial nerve can be closed by excision of unhealthy tissue and direct anastomosis, displacing the nerve forwards to lie across the promontory, in front of and below the oval window. In these circumstances perineural sutures may be necessary. A 10/0 ophthalmic suture on a 5 mm atraumatic needle is suitable.

In most cases an autogenous graft is a better solution, enabling the nerve repair to rest in the original bony canal.





12

11

12

If in the presence of good cochlear function excision of a post-traumatic 'neuroma' would incur a risk of stapes footplate dislocation or disrupt an acoustically effective myringostapediopexy, a long graft may be routed above and behind the lateral canal, leaving the 'neuroma' and the stapes undisturbed.

Postoperative care

This should be minimal as regards physical disturbance of the middle ear or mastoid cavity.

Short term dexamethasone by mouth may be helpful in minimizing intraneural fibrosis and should be given unless there are significant contraindications.

Recovery cannot be expected to begin in less than 3–4 months, unless simple decompression has been done before denervation. In some nerve graft cases re-innervation will not be evident clinically or electrically for as long as 6–12 months. After a well-performed repair hope of recovery should not be finally abandoned until 10–12 months have passed.

Illustrations by Daniel Slotton

Surgery of glomus tumours of the ear

B. Hill Britton MD
Associate Professor of Surgery (Otolaryngology), The Bowman Gray School of Medicine, Wake Forest University, Winston-Salem, North Carolina, USA

Introduction

A glomus tumour of the ear ordinarily presents as a pulsating, vascular, spongy mass in the middle ear space or in the external auditory canal. Clinically these lesions may be separated into two groups: glomus tympanicum tumours and glomus jugulare tumours. Microscopically they are the same. This distinction is based solely on the site of origin and areas of extension within the temporal bone. The microscopic description of these tumours has been well documented in the literature since the initial report by Rosenwasser[1] (currently, paraganglioma is the preferred name for these tumours) and will not be reviewed in this chapter.

Glomus tympanicum tumours are those tumours felt to arise in the middle ear space, most likely along the course of the Jacobson's nerve as it travels over the promontory of the middle ear. These may fill the entire middle ear and extend medially and laterally to the facial nerve, as well as into the epitympanum and the antral areas. Most often they do not involve the jugular bulb, but they may be immediately adjacent to it.

Glomus jugulare tumours are those felt to arise from the glomus structures along Jacobson's nerve or Arnold's nerve, deep in the bone forming the roof of the jugular fossa. These tumours involve the wall of the jugular bulb very early in the course of their growth. At later stages they often invade the lumen of the jugular vein or compress the jugular vein by external compression. They may secondarily mushroom into the middle ear space and involve the mastoid, lying medial and lateral to the vertical segment of the facial nerve.

Not all vascular lesions that present in the middle ear space are glomus tumours. The possibility of other primary or metastatic neoplasms must always be considered. There are also several vascular anomalies that may appear as glomus tumours and must of course be differentiated from a true tumour by thorough preoperative evaluation.

One of these anomalies is a dehiscent jugular bulb with partial herniation of the jugular vein through a bony dehiscence in the hypotympanum. This may present as a visible pulsating blue mass in the middle ear space.

Another vascular anomaly is an aberrant internal carotid artery. In this condition a vascular tumour mass presents in the middle ear space in association with pulsating tinnitus. This mass is actually an aberrant carotid artery which ascends into the hypotympanic area immediately anterior to and paralleling the course of the vertical portion of the facial nerve. It then turns forward immediately beneath the stapes superstructure and courses forward into the Eustachian tube area towards the normal carotid canal and petrous apex. The carotid artery in this anomaly may actually show fusiform dilatation in its middle ear course.

Another vascular lesion which has been described in the literature is a true aneurysm of the internal carotid artery. Apparently in this condition the thin bone between the middle ear space and the ascending portion of the carotid artery is eroded, and an aneurysmal sac from the carotid fills the middle ear space. It is obviously very important to consider these lesions in a differential diagnosis of the glomus tumour as well as to attempt to categorize the glomus tumour as to site of origin and extent through an extensive preoperative evaluation.

Preoperative

Symptoms

The common symptoms of a glomus tumour are pulsating tinnitus, hearing loss, and perhaps intermittent bloody discharge from the external auditory canal if the tumour has eroded through the tympanic membrane. Occasionally pulsating tinnitus is the only noticeable symptom to the patient. Facial paralysis or weakness is rare in spite of quite a large tumour. Pain may be a symptom, although this is uncommon.

Examination

A thorough physical examination, including complete examination of the ears, nose and throat, is mandatory. It is also most important to assess cranial nerve function, particularly of the lower cranial nerves. Signs of involvement of the four lower cranial nerves usually indicate an extensive lesion eroding towards the foramen magnum. Grossly, a glomus tumour appears as a vascular, pulsating, soft mass in the middle ear space or external auditory canal. If the tumour mass is behind an intact tympanic membrane, a pneumatic otoscope is very helpful to detect the pulsating characteristic of the mass.

Radiological evaluation

Radiological examination serves two basic purposes: (1) to establish the correct differential diagnosis; and (2) to determine preoperatively the extent of the lesion. For the sake of clarity, the radiographic examination will be described in four categories: plain film techniques, standard tomographic techniques, angiographic techques, and computerized tomography.

Plain films of the temporal bone can be very helpful if the films are well taken and the patient well positioned. A particularly useful view is a modified base view, where the X-ray beam is directed underneath the mandible or through the oral cavity towards the jugular foramen under examination. In this manner it is often possible to obtain an excellent view of the detail of the jugular foramen and to detect any erosive changes. It is important to bear in mind that the finding of an enlarged jugular foramen is not necessarily pathological unless there is obvious erosion around the periphery of the foramen or the normal contour of the jugular foramen is distorted. The right jugular foramen is usually anatomically larger than that on the left.

Standard tomographic techniques, particularly with the use of the polytome apparatus, have been a great aid in the exact delineation of the bone destruction in these lesions. They allow thorough examination of the contour of the jugular foramen as well as of the bone structure in the hypotympanic area. The vertical or descending portion of the facial nerve canal can also be seen, as can the normal course of the bony canal of the internal carotid artery, thereby eliminating the possibility of an aberrant internal carotid artery. The anteroposterior, lateral and basc views are considered to be the most helpful. The most frequently performed angiographic examination is carotid arteriography in which radiopaque contrast substance is injected into the common carotid artery. Attention is directed to feeding vessels (usually the ascending pharyngeal artery) as well as to the characteristic tumour stain. Late injection films can be used to demonstrate normal or blocked venous drainage through the jugular bulb. The possibility of an aberrant internal carotid artery or internal carotid artery aneurysm can also be eliminated.

The introduction of computerized tomography has been a major advance in evaluating these lesions because of its ability to demarcate soft tissue, bone detail and major blood vessels. This technique has the additional advantage of demonstrating possible intracranial extension of the tumour.

Thorough evaluation of these patients, both clinically and radiologically, usually allows the surgeon to be certain of the correct diagnosis, and is essential in order to determine the extent of temporal bone involvement and plan the surgical approach accordingly. It also allows the surgeon to inform the patient about the possibility of neurological impairment postoperatively.

Selection of patients

Irradiation is useful in some patients in that it slows the rate of tumour growth and may even produce a temporary reduction in size of the tumour which may last for several years. Its effect on tumour mass is thought to be due to sclerosis of some of the small vessel walls, thereby reducing the size of the tumour. Very little change, if any, can be detected in the glomus tumour cells themselves. Irradiation should be used only in cases where total surgical resection is not feasible, either because of the anatomical extent of the tumour or because of some medical contraindication. In general, if a lesion appears to extend medial to the margins of the jugular foramen, towards the foramen magnum, it is felt to be unresectable. Irradiation is also the best choice for very elderly patients or those with severe cardiovascular impairment. Except in the above cases it is generally accepted that total surgical resection is the treatment of choice.

Choice of procedure

There are three basic surgical approaches: the transcanal approach, the transcanal and transmastoid (extended facial recess) approach, and the transcanal and transmastoid approach with upper neck dissection. The choice of approach is determined by the sites of tumour involvement. As will be seen from the following there is a certain degree of flexibility allowing the surgeon to pursue the pathology as far as necessary. These extensive approaches require that the surgeon be thoroughly familiar with the anatomy of the jugular foramen area. In

order to gain more knowledge of the regional anatomy, the reader is encouraged to study the excellent illustrated treatise by Goldenberg and to pursue cadaver dissections.

Glomus tympanicum tumours can be managed by approaching the lesion without need for ligating the jugular vein or entering the lumen of the jugular vein. For very small lesions, limited to the promontory, a tympanotomy and removal of the tumour will be sufficient.

For larger glomus tympanicum lesions which are quite deeply rooted in the hypotympanum, a postauricular approach may have to be used, preserving the posterior bony canal wall and utilizing the extended facial recess approach. It may also be necessary to remove the retrofacial cells to approach the hypotympanum medial to the facial nerve. This is usually combined with a transcanal tympanotomy-type incision, which can be modified for a postauricular approach.

However, if the radiographic findings indicate a massive lesion with blockage or external compression of the jugular vein (glomus jugulare), then the operator must be prepared to ligate the jugular vein and possibly the external carotid or ascending pharyngeal artery in the neck as well as to pack the proximal segment of the sigmoid sinus in the mastoid area. It is also necessary to enter the lumen of the sigmoid sinus in order to gain entrance to the jugular bulb area for resection of the tumour and the superior and lateral wall of the vein. Bleeding in the jugular bulb area is usually quite extensive as there are many venous tributaries in this area that bleed vigorously. Ligation of the external carotid artery or ascending pharyngeal artery has not been as much help in decreasing bleeding as hoped for.

With very extensive lesions, perhaps invading the labyrinth, or adjacent to the ascending internal carotid artery, it may be necessary to remove the posterior bony canal wall and create an open-cavity radical mastoidectomy surgical exposure. In some cases it may also be necessary to remove the bone around the facial nerve in

its horizontal and vertical segments and reflect the nerve out of its canal in order to gain additional exposure of the hypotympanic and perilabyrinthine areas. Indeed, the sheath covering the facial nerve can be removed if necessary because of involvement by the tumour. It is unusual for the tumour to invade either the facial nerve sheath or the facial nerve fibres. If the nerve is involved, the affected segment may be resected with insertion of a segmental greater auricular nerve graft.

Using these techniques, it is possible to resect the entire jugular bulb area and a portion of the medial wall of the jugular foramen quite safely.

Another major area of concern is involvement of the ascending portion of the internal carotid artery. Here every attempt should be made to grossly remove as much tumour as possible from the wall of the carotid artery. The wall should then be frozen, using the cryosurgical unit. This has been done in several cases and re-exploration after several years revealed no evidence of residual tumour along the wall of the carotid artery. The cryosurgical technique is felt to be relatively safe because it does not produce through-and-through necrosis of the wall of the internal carotid artery. The continual flow of warm blood through this vessel during the freezing procedure prevents damage to the entire wall thickness. Cryosurgery may also be helpful for residual tumour in the jugular bulb area, particularly around IXth, Xth and XIth cranial nerves. It is possible to freeze around these nerves. There is usually good functional recovery of the resultant temporary paralysis, although this is slow and may take up to one year. In other areas of the middle ear space mastoid cryosurgery does not seem to be as effective in decreasing blood loss.

In some cases it may be necessary to remove the tympanic membrane and possibly the malleus and incus. The tympanic membrane can then be reconstructed with a temporalis fascia graft.

The operations

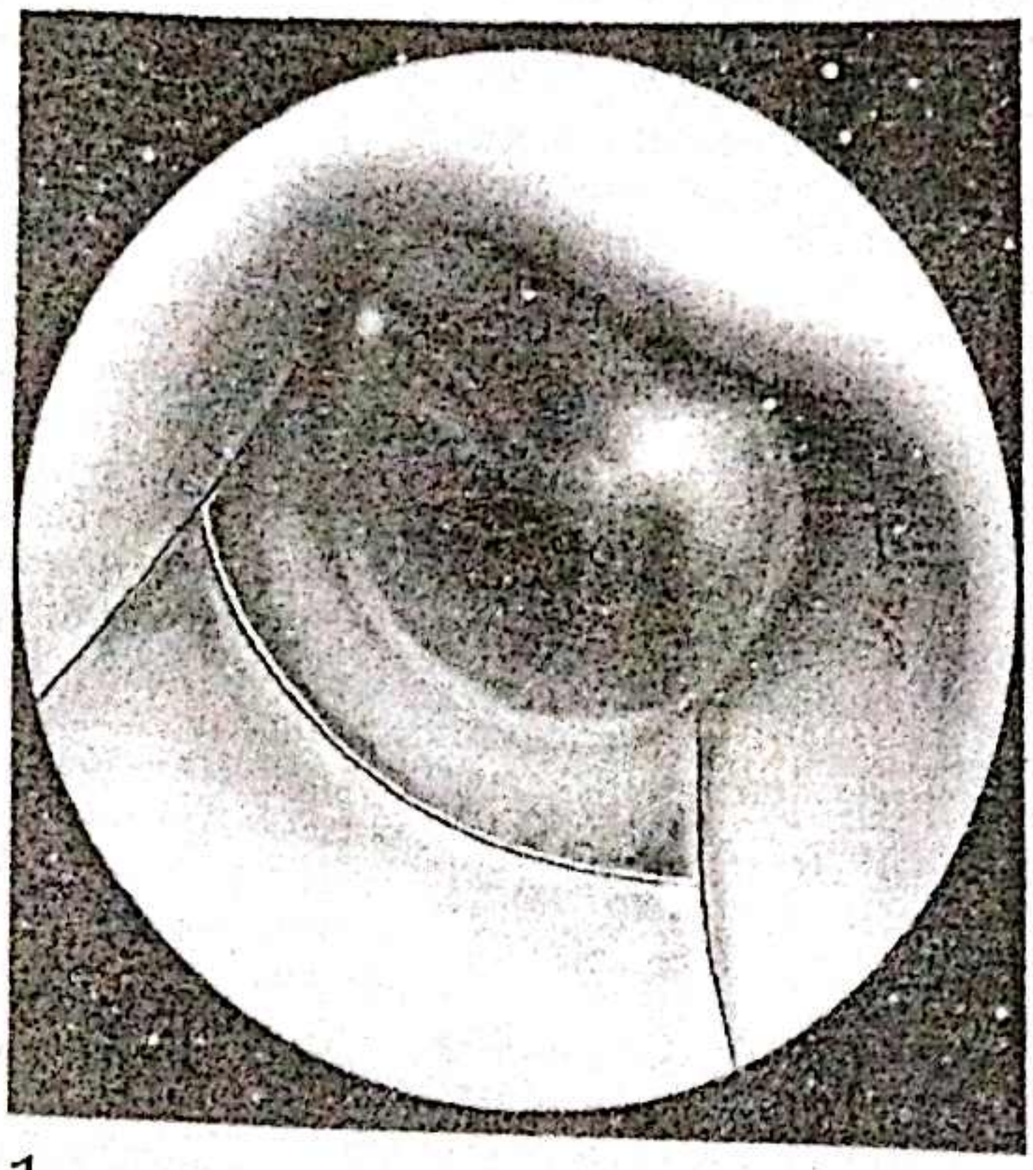
TRANSCANAL APPROACH

Indications

This technique is suitable for tumours confined to the middle ear space, where all margins of the tumour can be seen through the intact tympanic membrane (glomus tympanicum).

Anaesthesia

The procedure can be carried out under local anaesthesia, using 1 per cent lignocaine (lidocaine; Xylocaine) with adrenaline (epinephrine) 1:100 000.



1

1

The tympanomeatal flap incision is outlined. The canal skin and tympanic annulus are carefully elevated using blunt and sharp dissection. Only medial incisions are necessary, unless a postauricular approach is used, when the lateral incision should be completed to form a posterior meatal skin flap. The tumour is exposed in the middle ear space and removed with cup forceps. Bleeding is controlled with spot bipolar cautery or packing with oxidized cellulose. It may be helpful to elevate the tympanic membrane from the malleus handle for additional exposure. Closure is obtained by replacing the tympanomeatal flap and lightly packing the external auditory canal with Gelfoam impregnated with antibiotic ear drops.

TRANSCANAL AND TRANSMASTOID (EXTENDED FACIAL RECESS) APPROACH

Indications

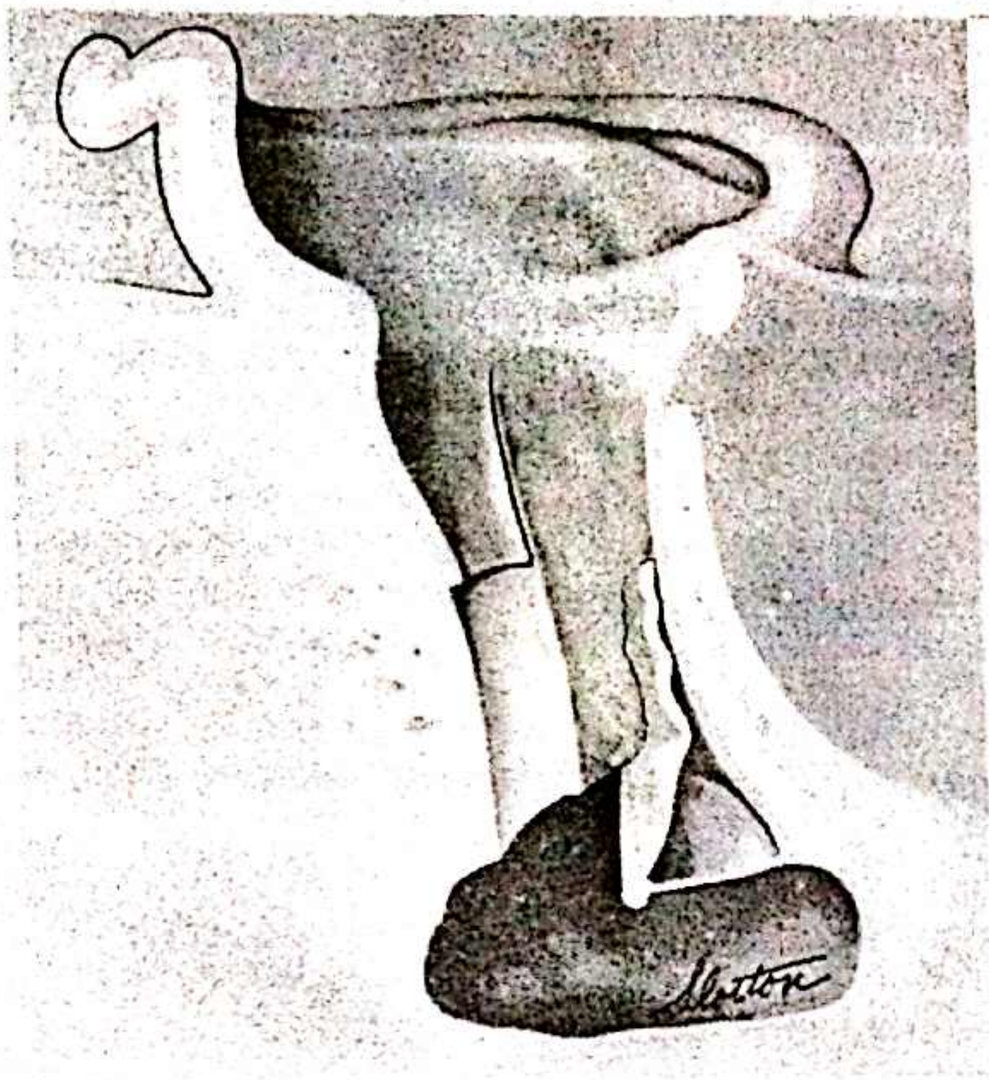
Glomus tympanicum tumours deep in the hypotympanum and possibly extending into the mastoid, but not involving the jugular bulb, are best managed by a transcranial and transmastoid approach.

Anaesthesia

This procedure requires general anaesthesia.

2 & 3

A slight modification of the tympanomeatal flap is required when a postauricular approach is also to be used. (*See Illustration 1* for the transcanal appearance of these incisions.) The incision lines have an 'H' configuration, with the superior longitudinal incision being made at approximately 12 o'clock and the inferior incision at approximately 7 o'clock. The transverse incision between these longitudinal incisions is made at approximately the mid-canal position. The posteriorly based skin flap at the meatus is then elevated from the external auditory canal and turned forward with the auricle when the post-auricular incision is completed. The medial flap is now elevated to expose the middle ear.

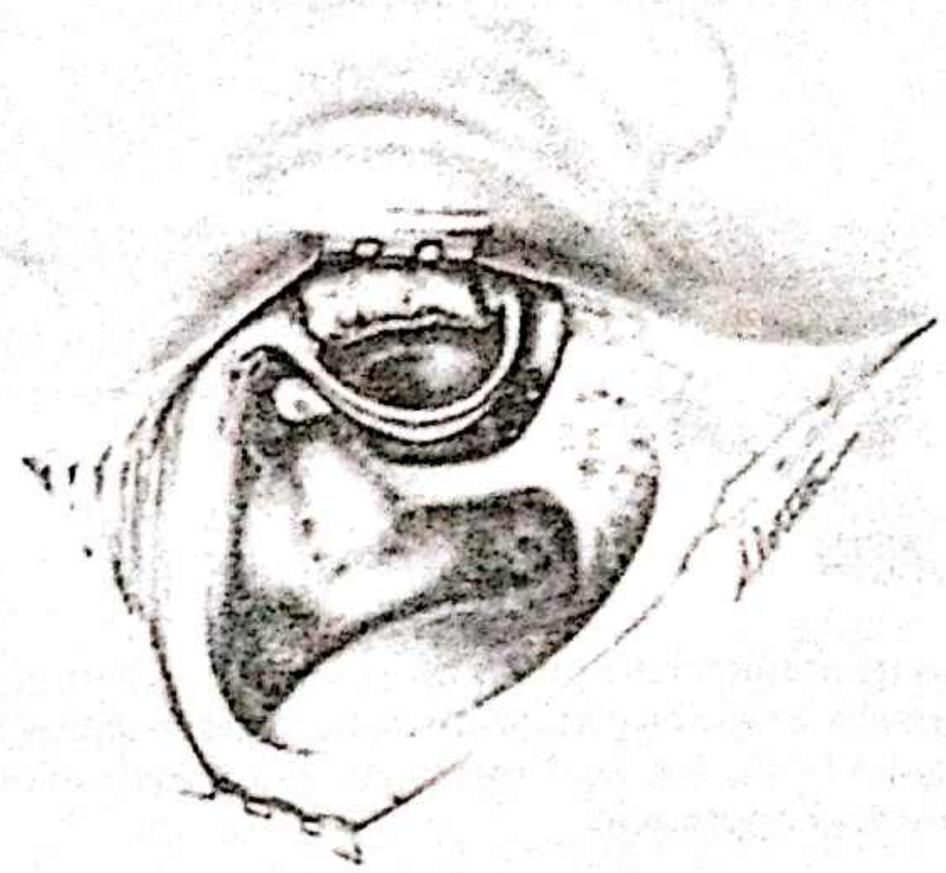


2

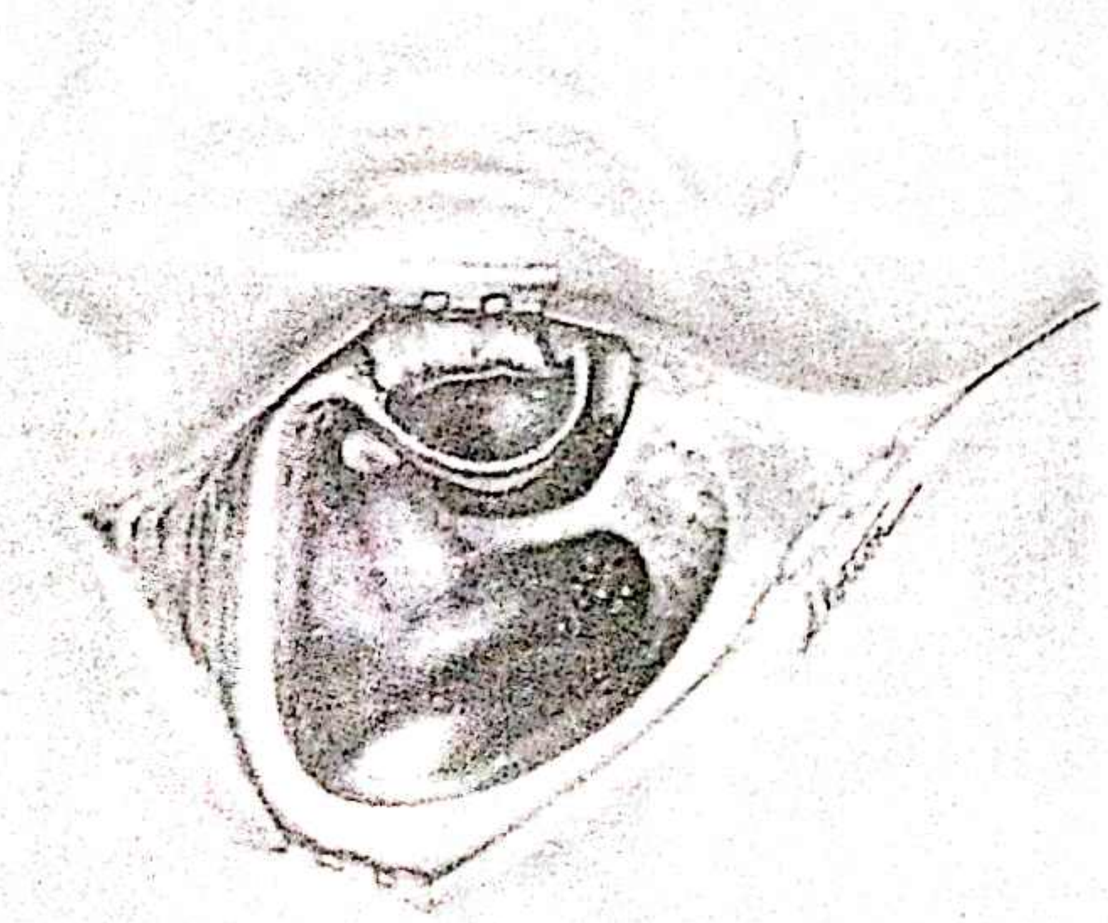
3

4

The mastoidectomy is completed with preservation of the posterior bony canal wall. Constant suction-irrigation with various-sized cutting and diamond burrs is essential. The extended facial recess has been opened. This exposes the hypotympanum by removing bone from the fossa incudis superiorly to the stylomastoid foramen inferiorly. The medial margin is the vertical segment of the facial nerve. Bone removal is then continued beneath the floor of the external auditory canal, thereby gaining access to the hypotympanum from a lateral approach. The anterior and superior margins of this bone removal are the annulus tympanicus and the posterior and inferior external auditory canal walls.



4



5

If further exposure of the posterior hypotympanum is required, or if the tumour itself is invading medially to the facial nerve, it may be necessary to remove the retrofacial cells. The tumour mass itself is removed using cup forceps, curettes and occasional sharp dissection. Bleeding is controlled with spot bipolar cautery or packing with oxidized cellulose. To obtain closure the posteriorly based meatal skin flap is then placed back into the external auditory canal and the tympanomeatal flap medially is also replaced. The entire canal is packed with Gelfoam saturated with an antibiotic ear solution. Normally no drain is used. The periosteum and subcutaneous layers are closed with inverted sutures of 2/0 plain catgut. Skin sutures are not usually necessary.

5

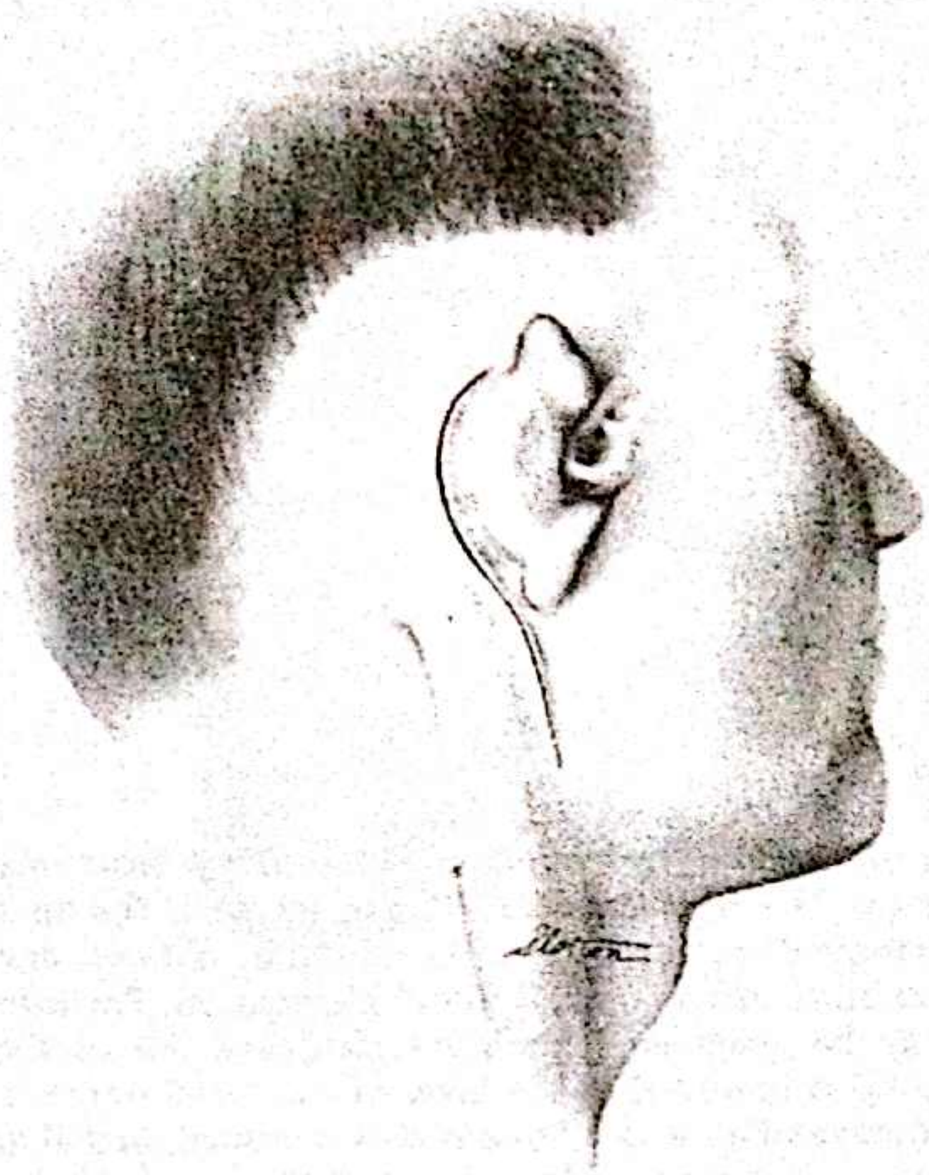
TRANSCANAL AND TRANSMASTOID (EXTENDED FACIAL RECESS) APPROACH WITH UPPER NECK DISSECTION

Indications

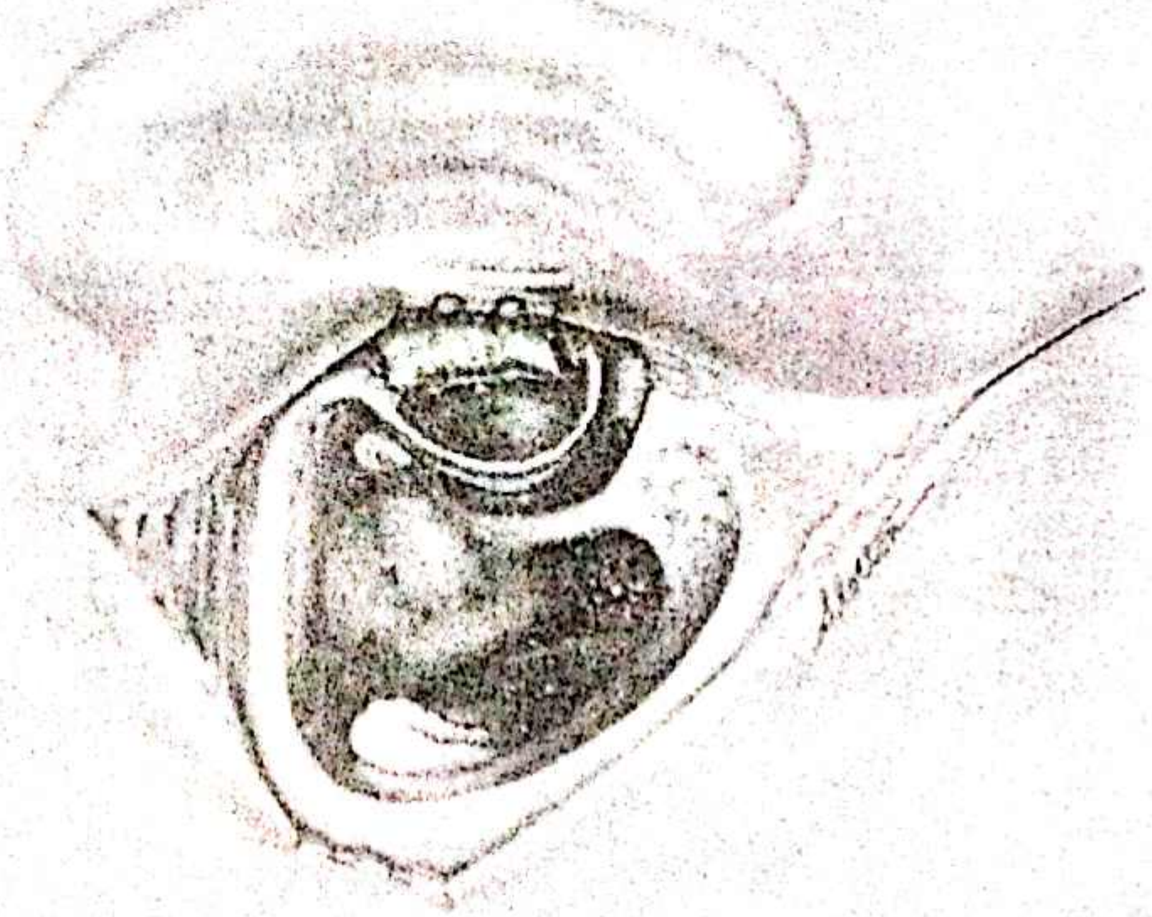
Extensive lesions with involvement of the jugular bulb wall or lumen (glomus jugulare) require additional dissection of the upper neck.

6

A long postauricular incision is made, extending into the upper third of the neck along the anterior border of the sternocleidomastoid muscle. The greater auricular nerve, which can be seen over the sternocleidomastoid muscle, may be used for a segmental facial nerve graft if necessary. For a detailed description of facial nerve grafting see the chapter on 'Surgery of the facial nerve (tympanic portion)', pp. 145–150. The preliminary dissection is carried out as shown in Illustrations 1–5.



6



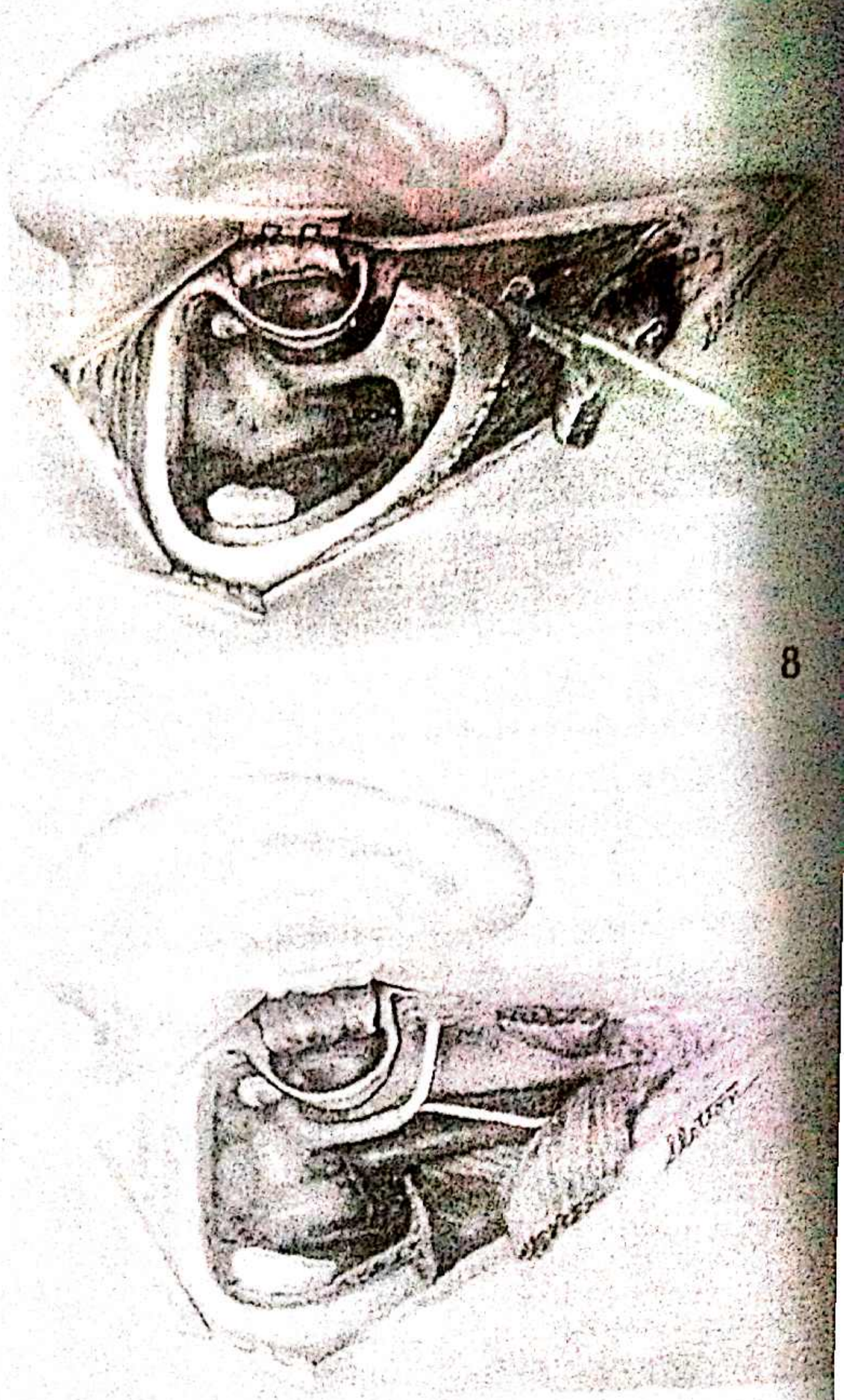
7

Oxidized cellulose is packed between the bone and the wall of the sigmoid sinus, producing extraluminal compression and obstruction of blood flow in this area.

7

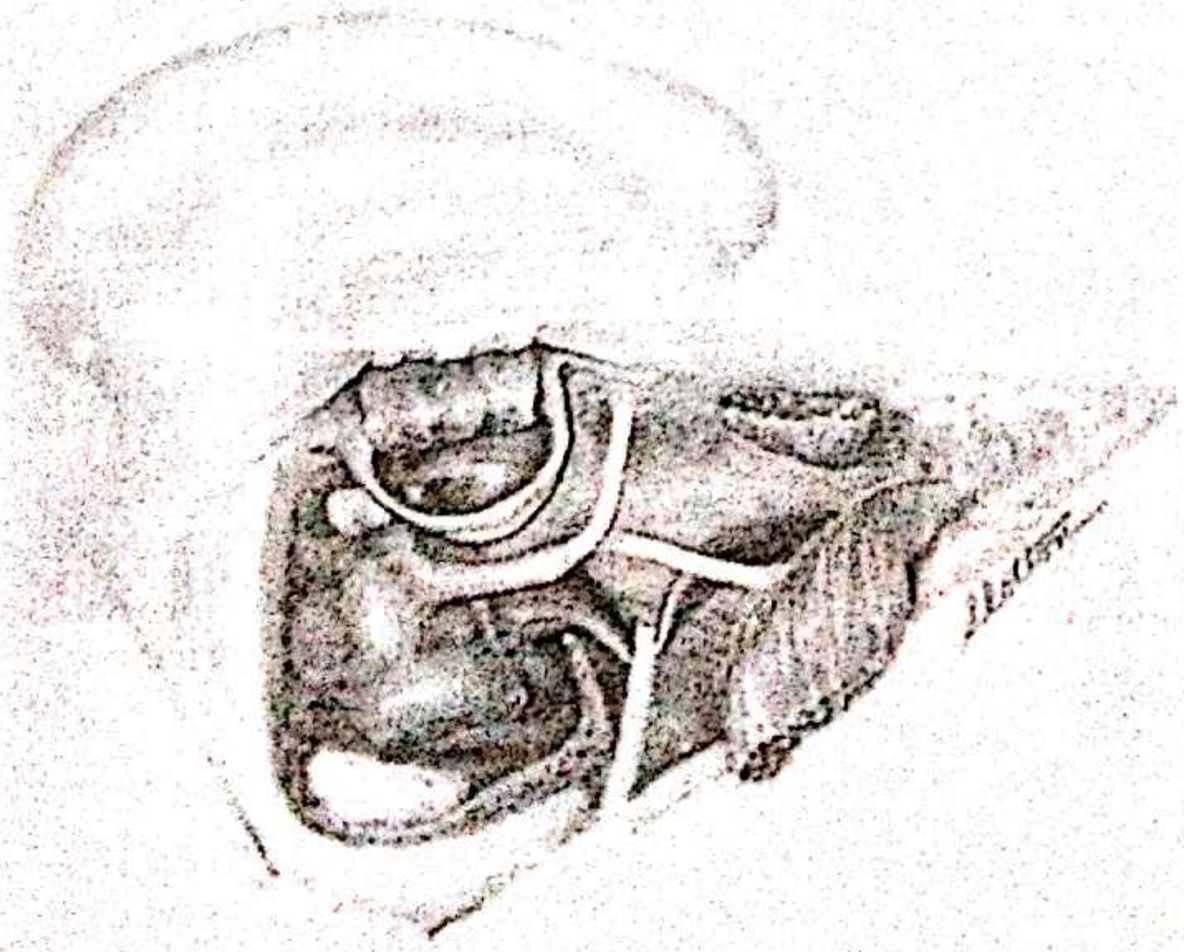
8 & 9

The sternocleidomastoid muscle is removed from the mastoid tip. The digastric muscle is also severed. The tip is then removed by drilling with multiple cutting and diamond burrs using constant suction-irrigation. Portions of it may be removed with bone rongeurs. All of the mastoid tip is removed to the level of the facial nerve in the stylomastoid foramen. Bone is also removed medial to the facial nerve between the nerve and the jugular bulb. This completely exposes the facial nerve in its vertical segment. The jugular bulb and jugular vein remain intact.



8

9



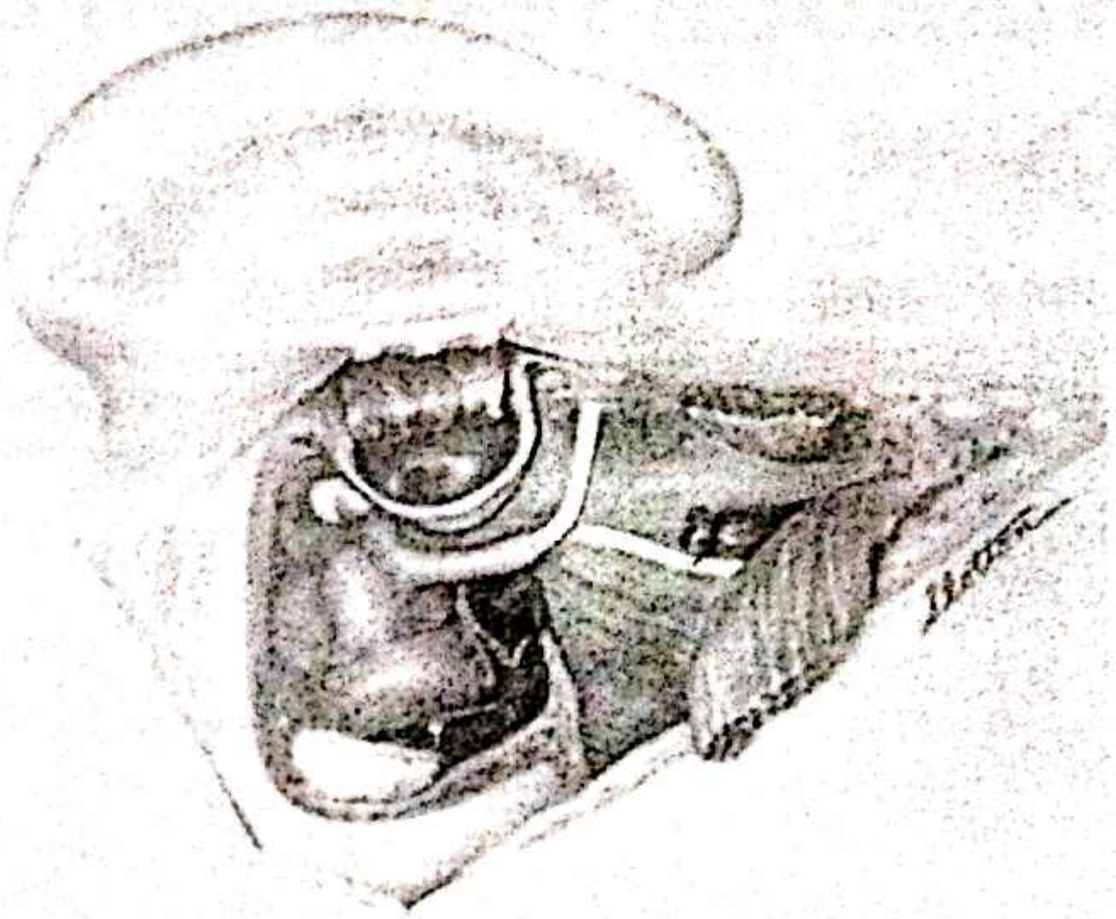
10

10

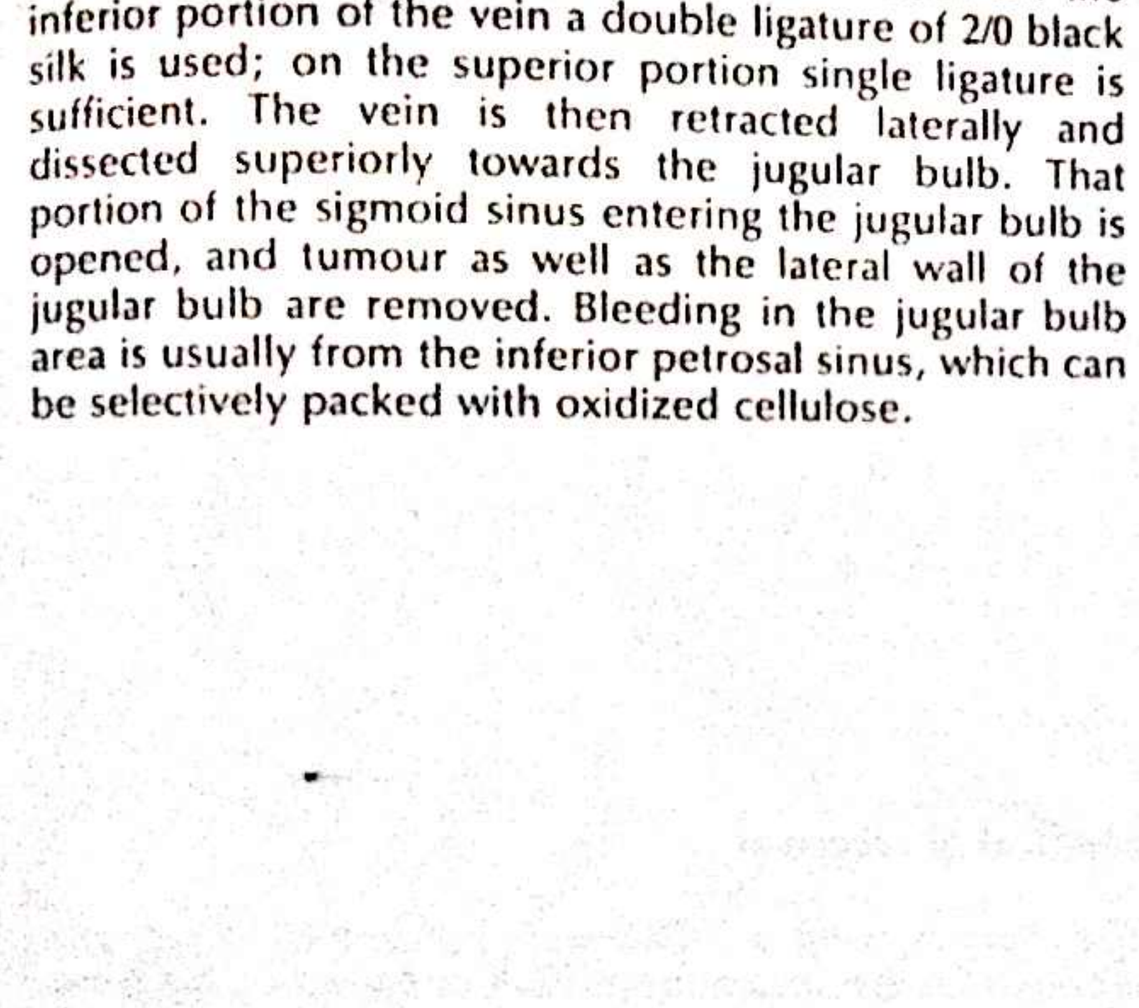
The jugular vein is isolated by careful dissection and a surgical tape then passed around the vein. Care is taken not to injure the vagus, the hypoglossus or the spinal accessory nerve.

11

The jugular vein is then ligated and transected. On the inferior portion of the vein a double ligature of 2/0 black silk is used; on the superior portion single ligature is sufficient. The vein is then retracted laterally and dissected superiorly towards the jugular bulb. That portion of the sigmoid sinus entering the jugular bulb is opened, and tumour as well as the lateral wall of the jugular bulb are removed. Bleeding in the jugular bulb area is usually from the inferior petrosal sinus, which can be selectively packed with oxidized cellulose.



11



12

It may be necessary to remove the bony posterior canal wall for additional exposure. Reflection of the facial nerve out of its horizontal and vertical bony canals will also increase exposure. For this, the bone lateral to the facial nerve in these areas is carefully removed using constant suction-irrigation and multiple-sized diamond burrs. The facial nerve can then be dissected free and lifted gently from its canal and turned forward. Any residual tumour around the IXth, Xth and XIth cranial nerves deep in the jugular foramen anteromedially can be effectively treated by application of a cryosurgical probe. This may also be used for residual tumour adherent to the wall of the internal carotid artery in the anterior tympanic space. Closure is similar to that used in the transcanal and transmastoid approach. However, it is helpful to insert an 0.75 inch (approximately 2 cm) soft Penrose drain into the lower portion of the neck incision. This drain is normally removed several days postoperatively. Closure is obtained by using multiple subcutaneous sutures of 2/0 plain catgut and skin closure with fine nylon or silk sutures.

References

1. Rosenwasser, H. Carotid body tumor of middle ear and mastoid. Archives of Otolaryngology 1945; 41:64–67

2. Goldenberg, R. A. Surgeon's view of the skull base from the lateral approach. Laryngoscope 1984; 94 (Suppl. 36): 1–21

Illustrations by D. R. Purnell

Subtotal resection of the temporal bone

John S. Lewis MD, FACS
Associate Professor in Otolaryngology, Columbia University;
Chief, Ear, Nose and Throat Service, Roosevelt Hospital, New York;
Associate Attending Surgeon, Head and Neck Service, Memorial Hospital, New York, USA

Preoperative

Indications

Subtotal resection of the temporal bone is indicated for:

1. Advanced cancer of the external ear involving the auditory canal and mastoid.
2. Advanced cancer of the external auditory canal with involvement of the middle ear and mastoid.
3. Cancer of the middle ear and mastoid, and
4. Cancer of the parotid with extension into the middle ear and mastoid.

Contraindications

The main contraindications are:

1. Radiological evidence of cancer involving the middle and posterior cranial fossae and base of skull beyond the jugular foramen level.
2. Cancer of the nasopharynx with extension into the middle ear.
3. Metastatic involvement of the mastoid from a distant primary source.

Method of removal

The operation is a combined extracranial/intracranial resection of the squamous portion of the temporal bone, petrosa, adjacent ascending ramus of the mandible and base of the zygoma with attached soft tissues.

Anaesthesia

Two malleable spinal puncture needles are inserted into the intrathecal lumbar spaces and attached by means of sterile tubing to sterile 30 ml syringes. During the procedure approximately 75–100 ml of cerebrospinal fluid will be removed. If spinal puncture is not possible, a diuretic agent such as frusemide (furosemide; Lasix) is helpful to decompress the brain from the petrous pyramid. Hypotensive anaesthesia is preferable. Sodium pentothal (thiopentone sodium) anaesthesia with maintenance of halothane or nitrous oxide is carried out.

Position of patient

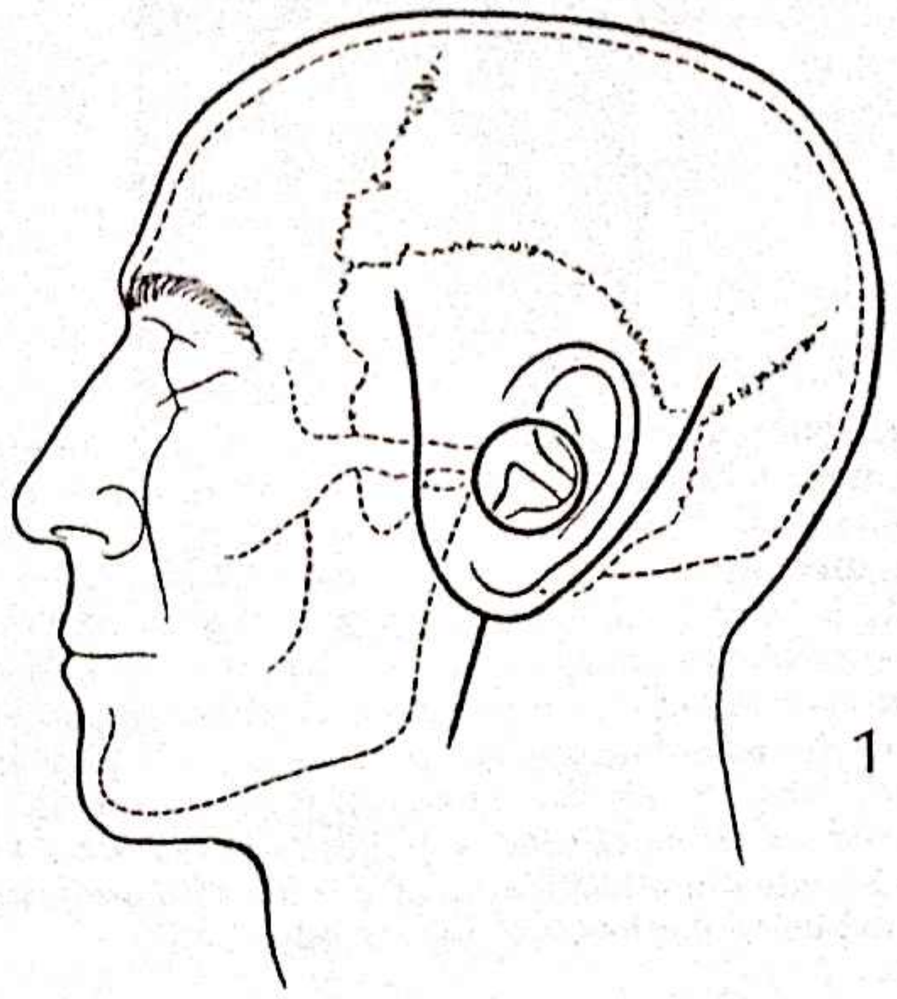
The patient's head is rotated to the opposite side and fixed in position. The hair is shaved to the midline and povidone iodine (Betadine) is used to sterilize the skin.

The operation

1

The incision

A U-shaped incision is made through the skin, superficial fascia and temporal muscle. A circular incision is made around the external auditory meatus if the external ear is to be preserved for cosmetic reasons.

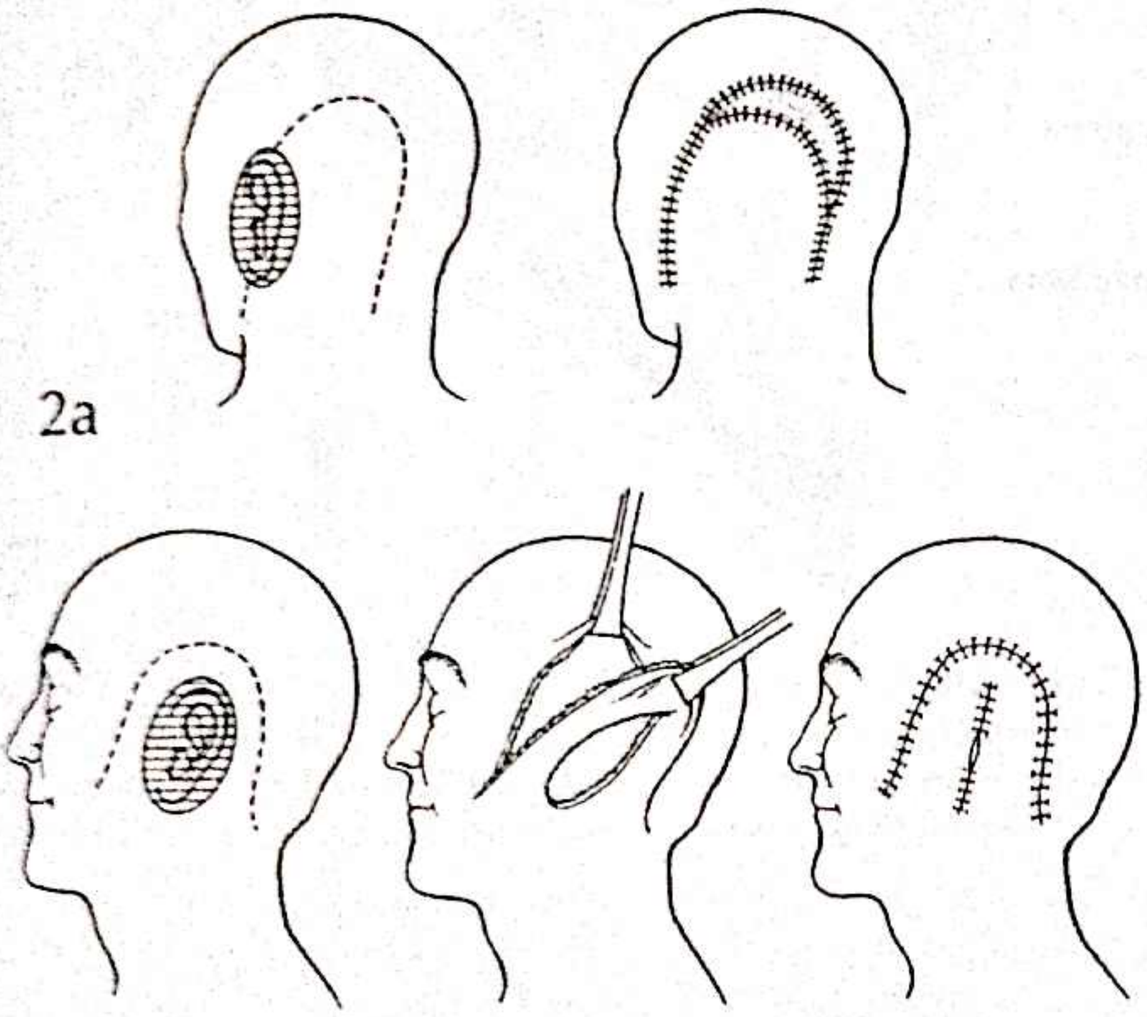


1

2a & b

If the external ear must be sacrificed because of cancer involvement, a posteriorly-based parietal-occipital flap can be rotated forward to cover the defect (*a*). The donor site can be grafted with a split thickness graft.

Alternatively a bipedicled flap can be used which can be closed in the midline to cover the defect (*b*).

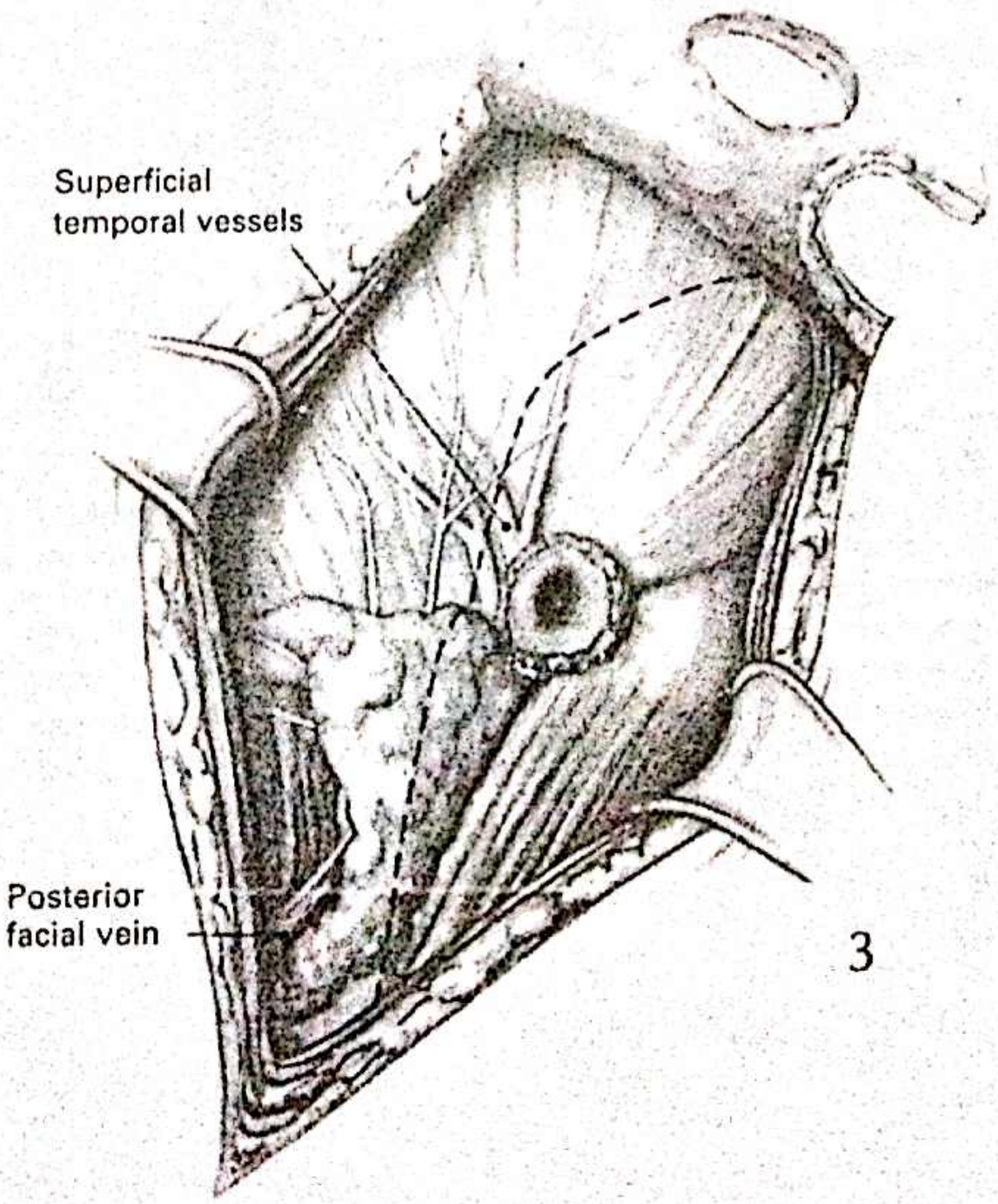


2a

2b

3

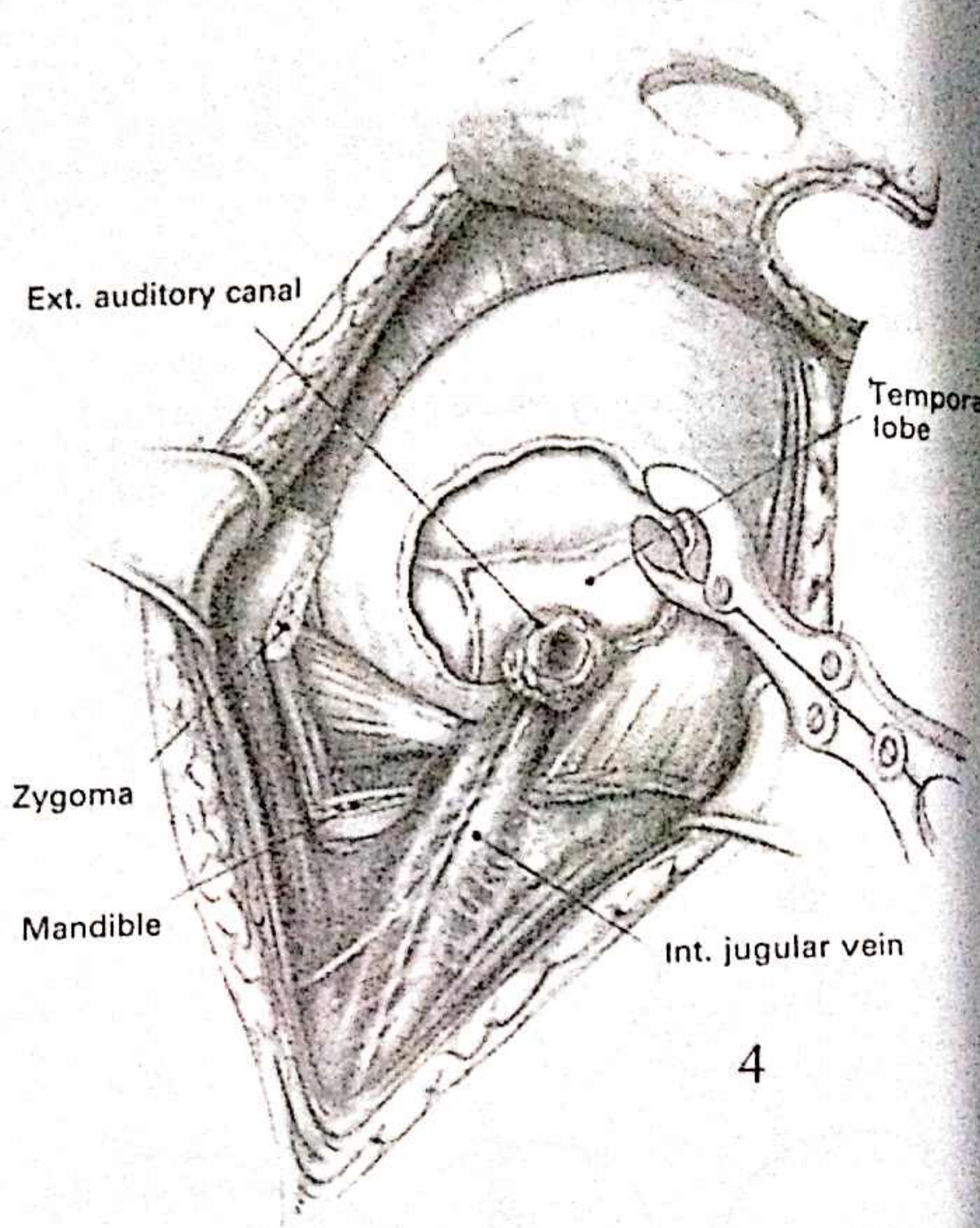
The skin flap is elevated and, along with the underlying deep tissue, rotated downwards. The external auditory canal is transected at the level of the auditory meatus and the entire flap sutured to the drape with heavy black silk. The superficial temporal artery and parotid are transected to expose the underlying zygoma and temporomandibular joint.



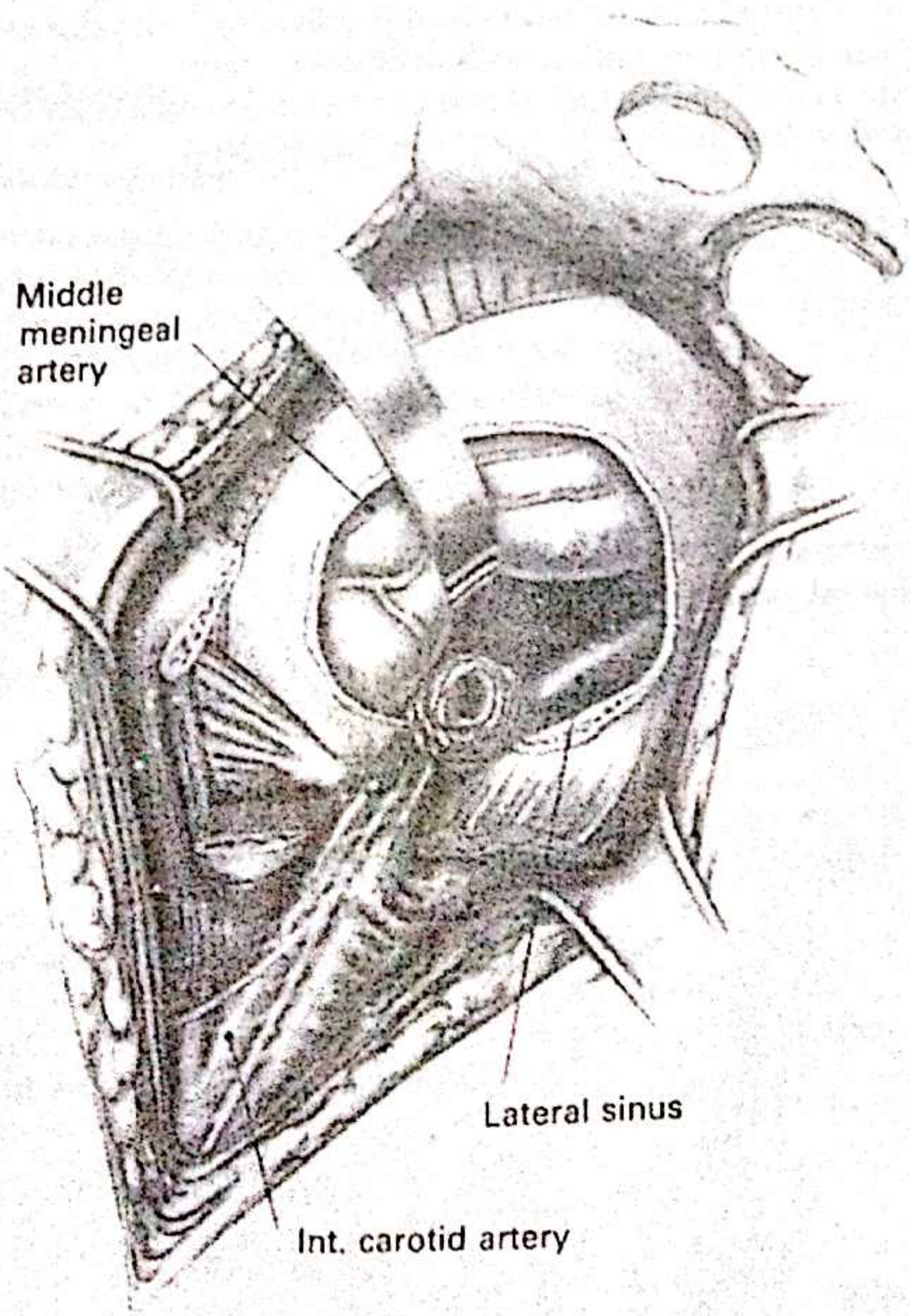
3

4

The temporal squamosa is skeletonized and a temporal craniectomy is carried out. The lateral sinus is exposed posteriorly. The petrosal vessels are coagulated. The middle meningeal artery may be electro-coagulated if bleeding is troublesome. Bleeding from the lateral sinus can be controlled with 0/0 surgical silk sutures. The base of the zygoma is skeletonized and transected. The ascending ramus of the mandible and temporomandibular joint are exposed. The ascending ramus of the mandible is transected at its neck and will be resected with the specimen. Muscle attachments of the mastoid are transected, exposing the internal jugular vein.



4



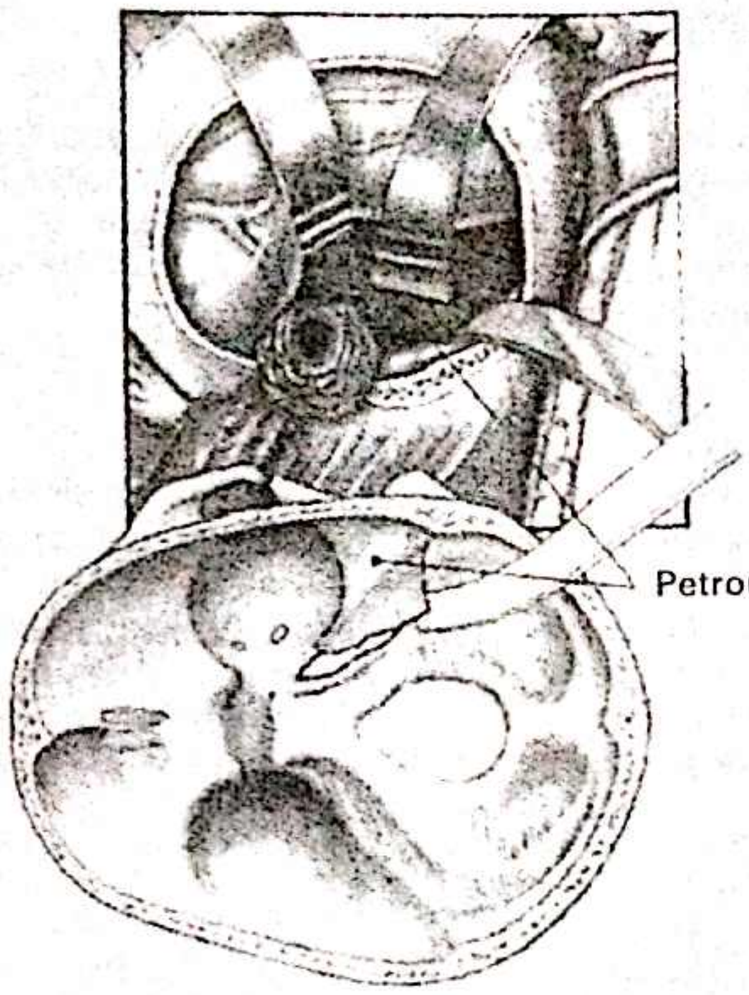
5

Approximately 75–100 ml of cerebrospinal fluid is withdrawn through the spinal puncture needles. The dura is elevated from the underlying petrous portion of the temporal bone.

5

6

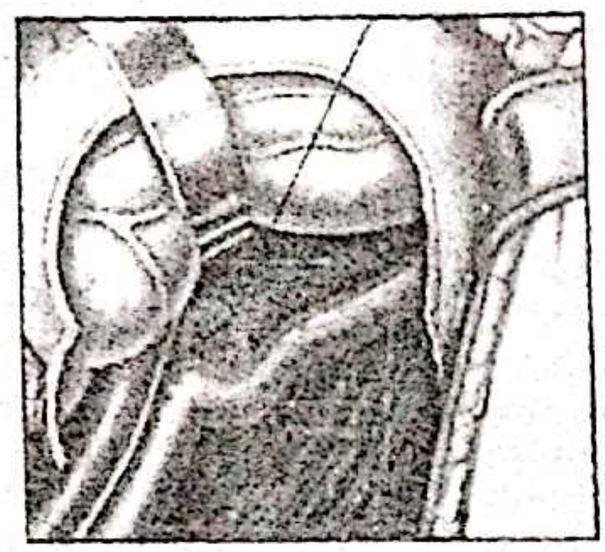
A high-speed air drill is used to exenterate the mastoid posteriorly, and the petrous pyramid is transected at the junction of the medial and middle thirds. The specimen is resected with heavy Mayo scissors.



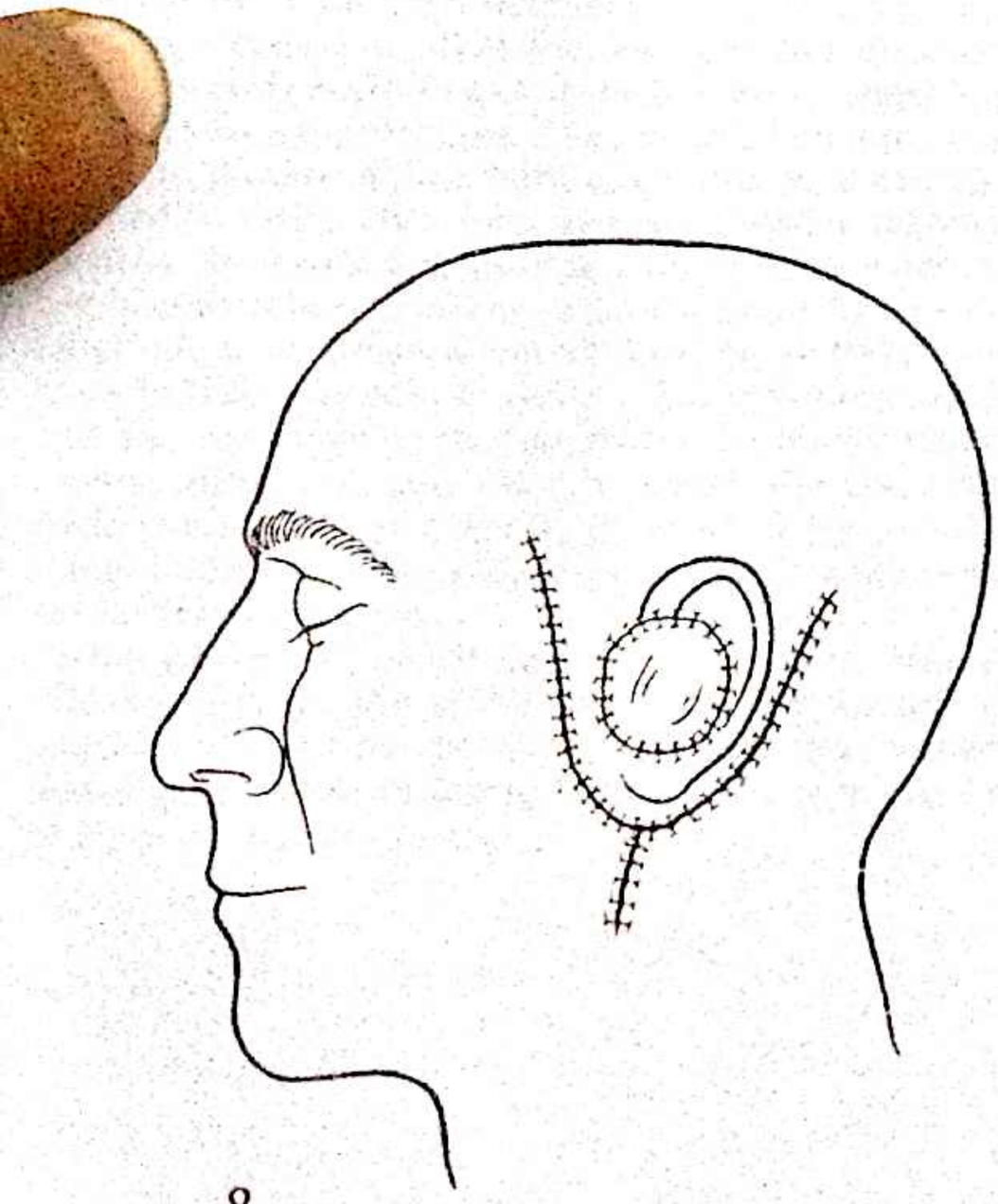
6

7

Bleeding areas are controlled with vascular silk and electrocautery. The internal carotid artery is visualized or palpated at the base of the defect. If bleeding from the lateral sinus is extensive this may be packed with Surgicel.



7



8

8

A split thickness skin graft of about 0.4 mm (16/1000 inches) is taken from the thigh with an electric dermatome. The skin graft is sutured into the new temporal canal with interrupted nylon sutures and a stent placed into the canal. A bulky gauze dressing is placed into the wound. A lateral tarsorrhaphy is carried out to prevent corneal ulceration due to subsequent facial nerve paralysis.

Postoperative care

The patient is kept flat in bed with intravenous fluids for 24 hours. Analgesics are administered as necessary. The patient should be kept under close observation in the recovery room for 24 hours postoperatively and the vital signs noted every 15 minutes.

Complications

1. Primary haemorrhage should be controlled at the operating table and is usually venous in origin. The lateral sinus bleeding can be controlled with surgical silk and Surgicel. Blood replacement is given as appropriate and approximately 1500 ml of whole blood is usually required. Cerebrospinal fistula if persistent for more than 3–4 days requires exploration of the wound and closure of any dural tear. This is important to obviate the occurrence of meningitis.
2. Infection may be due to Gram-negative organisms. A culture should be taken from the wound and appropriate antibiotics administered.
3. Vertigo can be controlled with the use of vestibular suppressants such as dimenhydrinate (Dramamine). It may last from 5 to 15 days although the period of unsteadiness can persist for several months.
4. Facial nerve function will be lost because of section of the nerve during the operation. A lateral tarsorrhaphy at the end of surgery will prevent corneal ulceration. A facial-hypoglossal nerve anastomosis may be carried out at the end of surgery. A facial sling procedure may be carried out at a later date as a secondary procedure.
5. Deafness is present in the involved ear because of obliteration of the middle and inner ear structures.

Illustrations by Gillian Lee

Ultrasonic treatment of Menière's disease

Jan Stahle MD, DSc
Professor and Chairman, Department of Otorhinolaryngology, Uppsala University, Akademiska Sjukhuset, Uppsala, Sweden

Introduction

As long as the pathogenesis of Menière's disease remains unknown, both the medical and surgical treatment must of necessity be symptomatic. Nowadays, in most patients, the condition can be satisfactorily controlled by different kinds of conservative measures. Surgery has to be considered in the small number of patients who, in spite of long-standing medical therapy, are still disabled by frequent and severe attacks of vertigo. When choosing the type of surgical procedure it has to be taken into account that the disease afflicts both labyrinths in about 25 per cent of all cases. Therefore operations which deliberately destroy the remaining hearing should be avoided. One method to achieve selective elimination of the vestibular labyrinth with preservation of hearing is to use ultrasound. This affects both the vestibular neuroepithelium and the secretory epithelium in the vestibular compartments. Thus, not only does it reduce the secretion of endolymph and, as a result, diminish the endolabyrinthine hydrops, it also depresses the function of the vestibular end-organs.

The whole art of ultrasonic treatment of Menière's disease rests on the ability to choose the optimal dose which will destroy or almost destroy the vestibular end-organs without causing further damage to the organ of Corti or the facial nerve.

Biological mode of action of ultrasound

Sound frequencies which lie above the limit of human hearing are known as ultrasound. In the treatment of Menière's disease 1 000 000 cycles per second (1 Mc/s) or more are used. The biological mode of action of ultrasound is complex. In general it seems to be based on three factors: (1) mechanical, (2) thermal, and (3) chemical. Expressed simply, the mechanical effect of ultrasound on tissue is to produce a shaking movement with destructive properties.

The thermal effect is a result of absorption of energy by tissues. Bone has a high absorption coefficient and therefore becomes very hot. Studies in patients have shown that 3 minutes of continuous irradiation with a power of 3 W against the enchondral bone increases the temperature in the lateral ampulla to 50 °C and in the vestibule to 45 °C.

In order to facilitate the transfer of sufficient energy the otic capsule must be thinned down to a clearly visible 'blue line'.

Routes of access

Lateral semicircular canal technique with cooling (wet cavity technique)

Following antrotomy, the beam is directed at a clearly visible 'blue line' on the lateral semicircular canal. The mastoid cavity and middle ear are filled with circulating saline, which cools the bone and conducts the ultrasound. This technique is designed for the 3-Mc machine used by the Angell-James group in Bristol.

Three semicircular canal technique (dry cavity technique)

The three bony semicircular canals are exposed after simple mastoidectomy. The otic capsule on the canals is thinned to a 'blue line', on which the beam is directed. The beam should be aimed at the ampullary regions. A very small drop of saline is used for coupling the tip of the ultrasound transducer to the target area. The rest of the cavity is kept dry. This technique is designed for the Ultrapoint machine used in Uppsala.

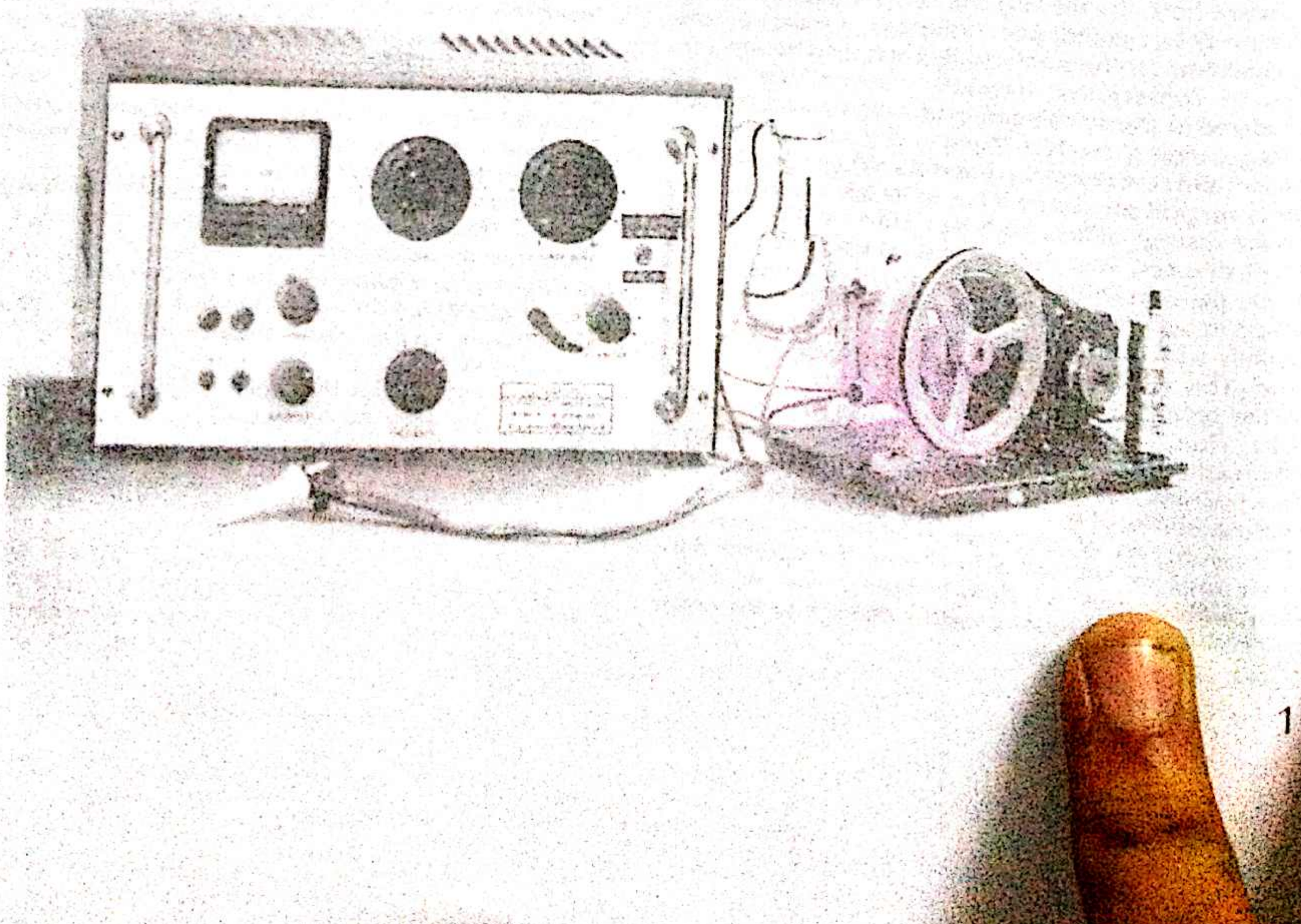
Round window technique

The middle ear is approached via the external meatus, and a very small, angled transducer is introduced and aimed at the round window. This route has many attractions, as the window membrane offers practically no interference. A considerable temperature rise both in the vestibule and in the cochlea can be expected, however, and subsequent hearing loss has been reported. The technique and equipment have been developed by Kossoff in Brisbane.

Ultrapoint ultrasonic irradiator

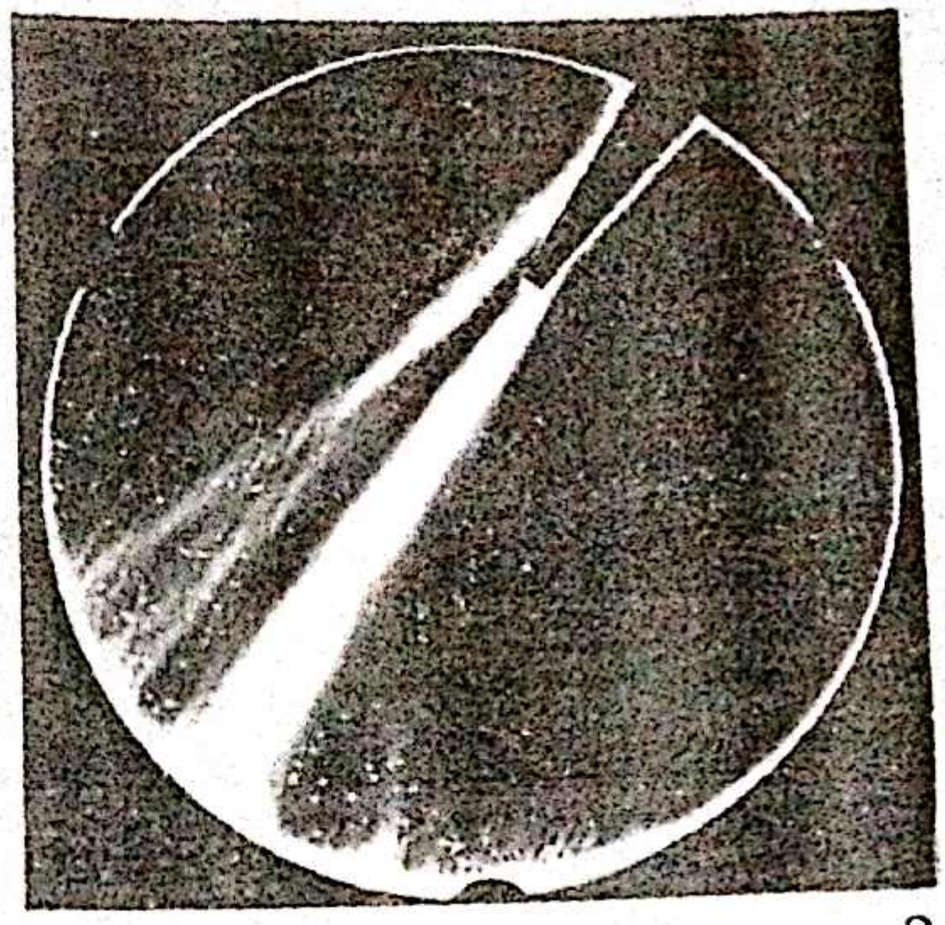
1

The ultrapoint ultrasonic irradiator is composed of two main parts: the radio frequency generator, consisting of an oscillator and a power amplifier (*left*), and the treatment head (the transducer) with its cooling system (*right*). High-frequency alternating current is transmitted from the oscillator to the transducer, where a small concave barium titanate disc converts the electrical energy into ultrasonic waves with a frequency of 1.25 Mc/s. A detailed description of the ultrasonic unit has been published elsewhere[1].



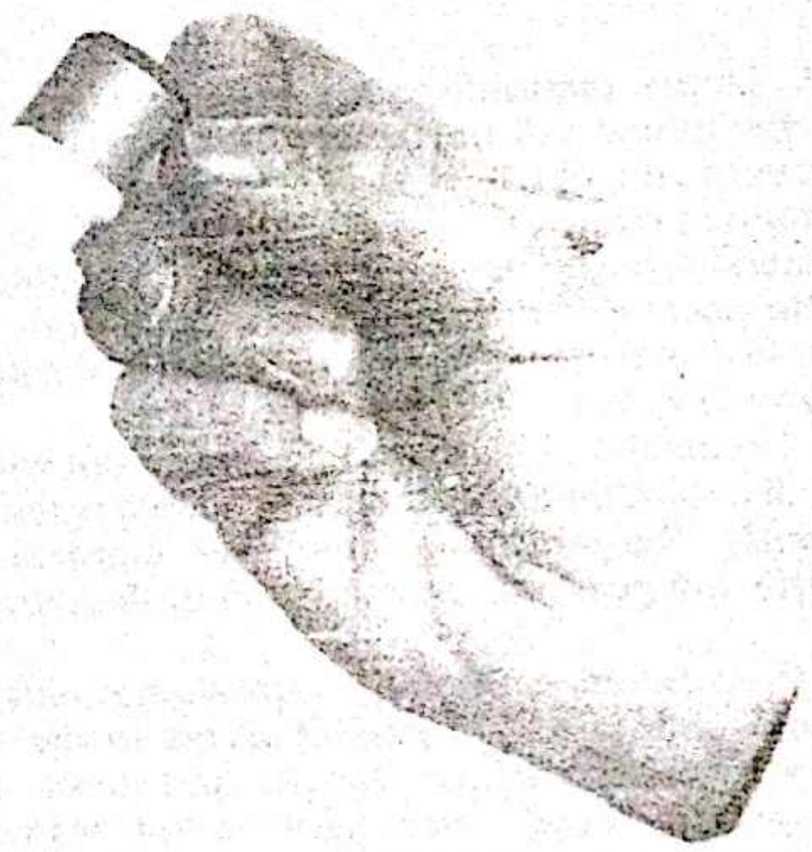
1

2



2 The ultrasonic beam can be photographed by means of a Schlieren optical reflecting system. The beam of rays is well concentrated, with its focal point just inside or at the flat tip of the transducer. A well-concentrated central beam is emitted from the tip, which at operation is aimed at the prepared 'blue line' on the semicircular canals.

3



3 The transducer has an interchangeable Teflon tip, the end of which has a diameter of 2.5 mm. Cooling is achieved by means of distilled degassed water, circulated by a special pump at about 200 ml/min. The cooling water in the Teflon tip conducts the ultrasound from the transducer to the thin membrane at the tip. Coaxial cable and circulation hoses can be seen extending from the handle.

The entire treatment head, together with the coaxial cable and circulating hoses, can be sterilized either by boiling or by autoclaving. No part of the unit to be handled by the operating surgeon therefore needs to be covered by sterile drapes.

Power output

The maximum power output of the Ultrapoint apparatus is about 4 W. This implies peak intensities of up to 80 W/cm^2. Irradiation is usually begun with a power of 3 W and gradually increased to 3.5 and 4 W during the operation if necessary.

Selection of patients

A choice has to be made between operations in which hearing is preserved and those in which it is destroyed. In general, destructive procedures such as Cawthorne's first and second operations and total labyrinthectomy should be regarded as a last resort. Because of the strong tendency of Menière's disease to afflict both ears, preservation of the remaining hearing should be the goal.

Ultrasonic treatment is recommended in patients with frequent vertiginous attacks completely resistant to medical therapy, who have a constant hearing loss and a negative glycerol or urea test. In patients with fluctuating hearing loss and a positive glycerol or urea test, a drainage operation on the endolymphatic sac is to be preferred.

The operation

The operation is best performed under local anaesthesia so that the function of the facial nerve and the nystagmus can be observed during irradiation.

4

The patient lies on his back with the diseased ear upwards. A large mirror is placed in front of the face to allow the surgeon to check facial nerve function and to study eye movements during the procedure. Wearing Frenzel's glasses during irradiation greatly facilitates observation of the nystagmus.

5

A simple mastoidectomy is performed and the bony labyrinthine wall and the antrum are exposed. The incus is identified and left in place. The bony labyrinthine wall is thinned out over the ampullary parts of the superior and lateral semicircular canals and also over the convexity of the posterior semicircular canal. The bony canal wall is drilled with a diamond burr so as to create a small flat groove to fit the tip of the transducer.

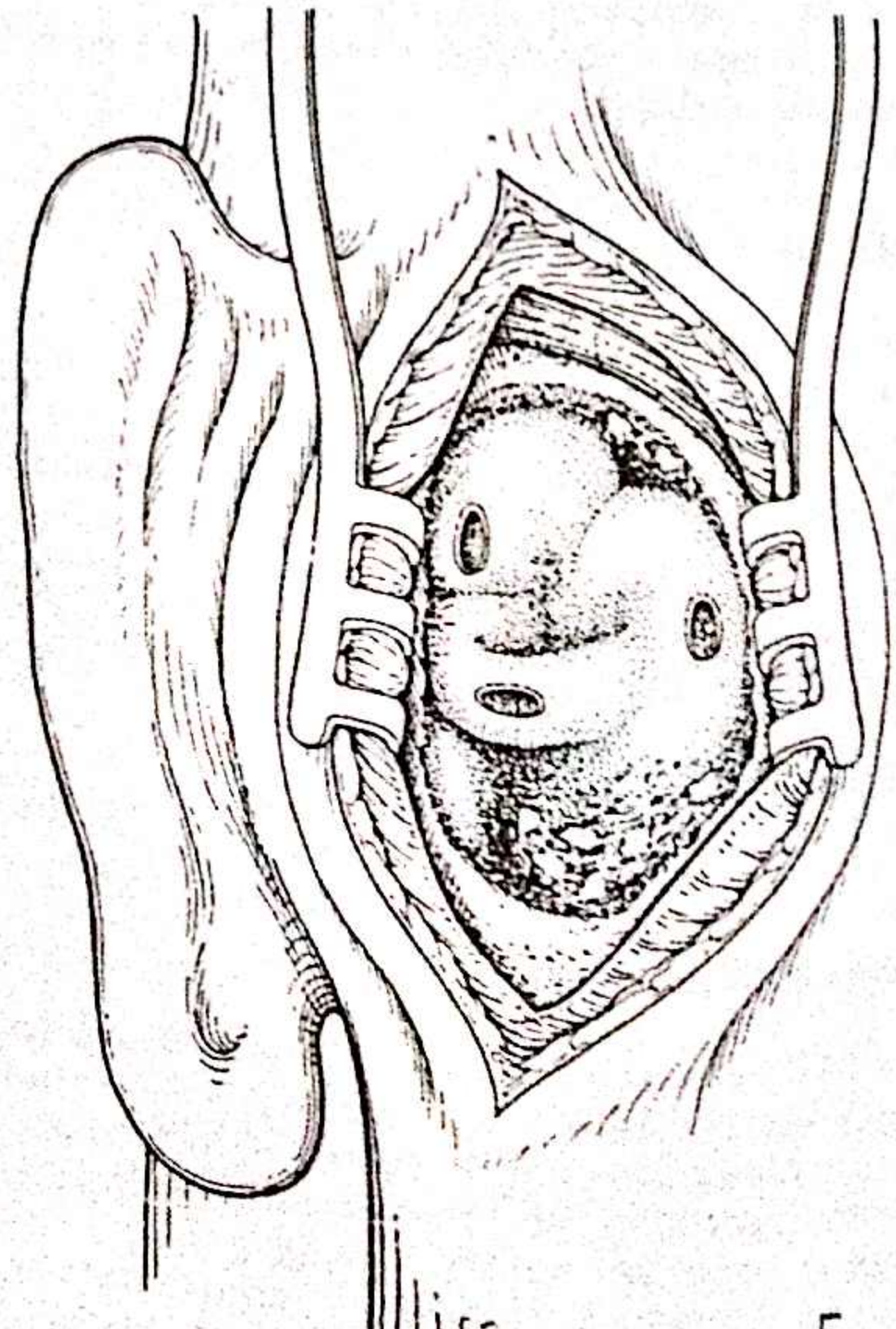
The final drilling should be carried out with a diamond drill until a 'blue line' (translucent wall) is seen on all three canals. The remaining bone layer approximately 0.5 mm thick will guarantee transmission of the ultrasonic beam.

In patients with very narrow mastoids it may be impossible to obtain perfect access to the superior and posterior semicircular canals, and bone thinning, as described above, may have to be restricted to the ampullary part of the lateral semicircular canal.

Before being applied to the grooves in the bony labyrinthine wall, the tip of the transducer is dipped in physiological saline solution so that a small drop attaches to it. This drop, which sometimes becomes mixed with a small amount of blood from the operation cavity, is used as a coupling medium between the transducer and the bony wall to facilitate transmission of ultrasound.

Irradiation of the superior and posterior semicircular canals, starting with 3 W, is given for 3-minute periods. The horizontal canal should not be irradiated for more than one minute at a time in order not to jeopardize the facial nerve and the cochlea. A short break between periods of irradiation is recommended to let the labyrinth cool down. Continuous irradiation for more than 3 minutes should be avoided because of the risk of undesirable hearing deterioration.

The total irradiation time is generally about 15 minutes and the total energy applied about 3000 J.



Nystagmus as an indicator of ultrasonic effect

At first, irradiation provokes homolateral or 'irritative' nystagmus, and the sensation of having a vertiginous attack in the patient. After 6–7 minutes of irradiation the irritative nystagmus usually begins to disappear, to be replaced by irregular eye movements. At the same time the feeling of discomfort is reduced. The power is then increased to 3.5 or 4W for the subsequent irradiation periods. If homolateral nystagmus reappears, irradiation should be continued intermittently until no further definite nystagmus can be provoked. At this stage a contralateral or 'paralytic' nystagmus can often be observed, indicating that destruction has been accomplished.

The wound is stitched in two layers, leaving a small drainage tube for 24 hours.

Postoperative care

Most patients feel slightly unsteady when standing and walking in the days following the operation. Severe nausea is rarely encountered. A nystagmus beating from the treated side can frequently be observed with Frenzel's glasses for 3–4 days postoperatively. Transient facial paralysis occurs in 1 per cent of patients. No other complications, such as meningitis, brain abscess or brainstem disturbances, have ever been noted. Haemotympanum lasting for several days is a common finding and requires no therapy.

Reoperation

In cases of failure, irradiation can easily be repeated. The cavity in the mastoid remains as one large air-filled cell. A delay of 6–12 months before reoperation is recommended. Ultrasonic treatment is also a valuable alternative after unsuccessful operations on the endolymphatic sac.

Reference

1. Johnson, S. J. An ultrasonic unit for the treatment of Meniere's disease. Ultrasonics 1967; 5: 173–176

Illustrations by Michel Portmann

Operations on the saccus endolymphaticus

Michel Portmann MD, HonFRCSI
Clinical Professor, University Clinic of Otorhinolaryngology, Bordeaux, France

Operations on the endolymphatic sac are designed to create a permanent fistula in the endolymphatic sac or to ensure expansion of the sac. This permits evacuation or expansion of liquid during a crisis in Menière's disease (endolymphatic hydrops).

Indications

The endolymphatic sac is opened only in well-selected cases of Menière's disease. The immediate relief of vertigo is excellent in more than 70 per cent of cases. Tinnitus is eliminated in only 25–30 per cent of cases. The hearing is always spared, and improved in 30 per cent of cases. The long-term results are less impressive but still very satisfactory. More than 55 per cent of patients never present again with vertiginous crises.

Since recurrences are not uncommon, this technique should be reserved for cases of vertigo that are known to be due to Menière's disease.

The diagnosis is established by clinical examination. Audiometric examination reveals a predominantly unilateral sensorineural hearing loss, maximum for the lower frequencies, and with a rise towards 2000 Hz. The presence of recruitment and higher level disturbances is confirmed by the Fowler test, Luscher test, positive SISI and a type II Békésy audiogram. The electronystagmogram agrees with the general deficit. If the hearing level is within the usable range (less than 60 dB loss) audition is conserved. A more radical procedure would produce better long-term results but must be avoided because it could lead to total deafness. Opening of the endolymphatic sac is therefore the best surgical solution in these patients. However, it is necessary to demonstrate that the usual medical treatment has failed to produce satisfactory results.

Preparation of patient

The endolymphatic sac is situated on the posterior wall of the petrous bone and is reached by drilling through the mastoid bone. The sac is opened on its outer surface. This results in decompression of the sac and thus prevents the effects of future crises in endolymphatic hydrops.

The patient is placed supine and the head is turned to the opposite side. The mastoid region is shaved and washed with an antiseptic solution. The external auditory canal is also washed and an antiseptic is instilled. Since it is necessary to perform a mastoidectomy, general anaesthesia is usually favoured, but the operation can be done under local anaesthesia. The surgeon is seated and the surgical field is illuminated either by the microscope light or by an overhead light. A surgical assistant is unnecessary but a nurse or technician should be available to prepare and pass the instruments on demand. The instruments used are those for a simple mastoidectomy, with the addition of a fine scalpel (Beaver) to open the sac.

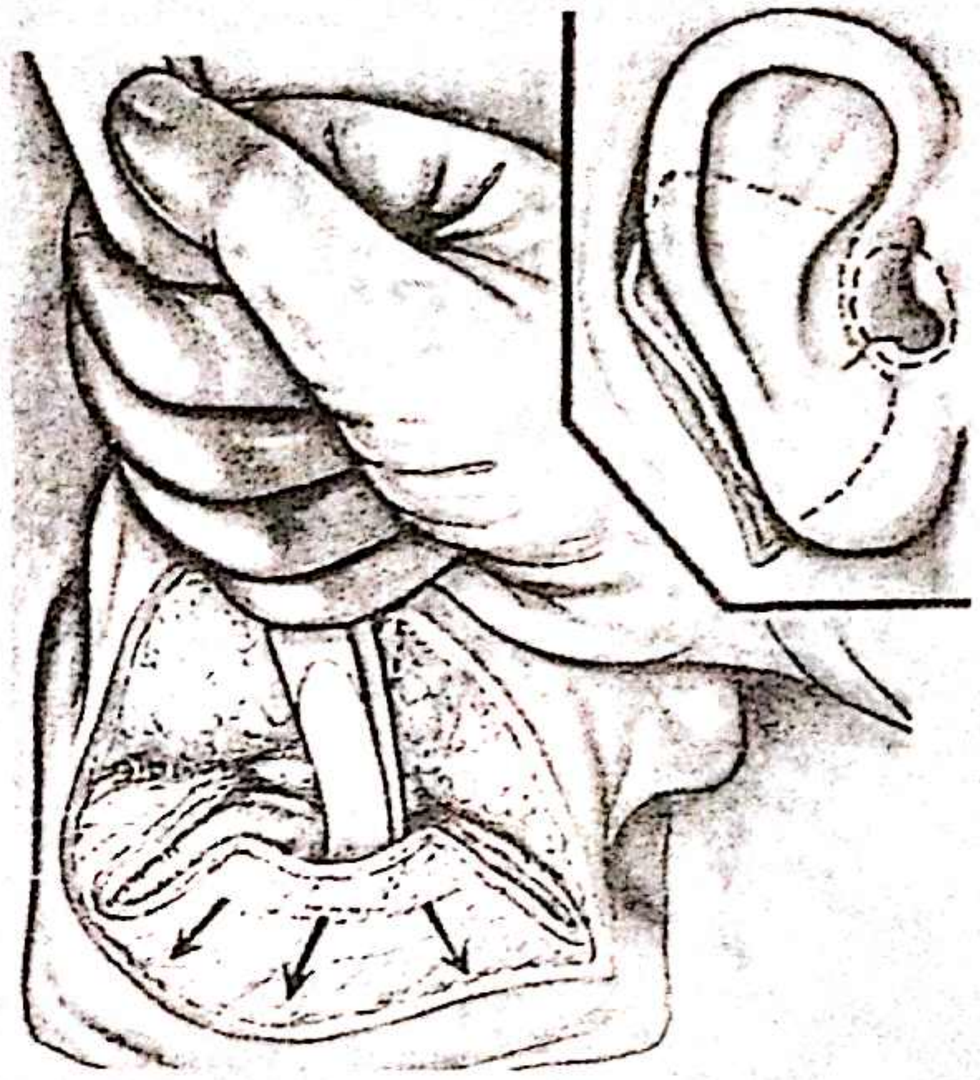
The operations

OPENING OF THE ENDOLYMPHATIC SAC (GEORGES PORTMANN TECHNIQUE)

Access through the soft tissues is identical to that used for simple mastoidectomy.

The incision

The incision is made in the retroauricular crease. It penetrates only through the skin and extends from the linea temporalis to a level corresponding to the inferior part of the external auditory canal.

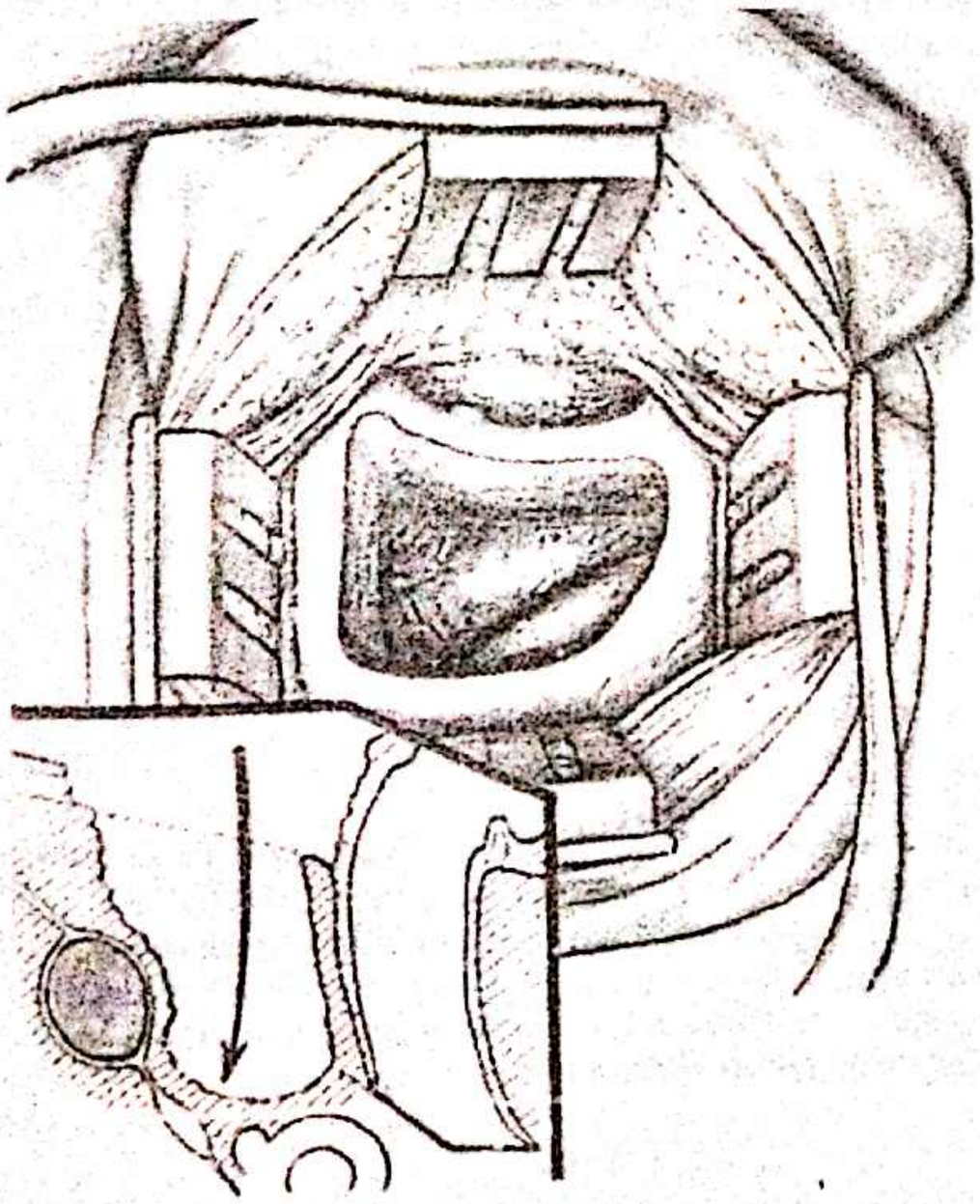


1

1

The cartilage of the pinna is separated from the musculoaponeurotic plane by an incision extending from the superior part of the external auditory canal above and forward, behind the pinna, and finally inferiorly to expose the bony surface of the mastoid. With the scalpel blade perpendicular to the bone around the external auditory canal (above and behind the external auditory canal), this incision is united obliquely with the tip of the mastoid.

The periosteal elevator is placed in the incision and the periosteum is separated from the bone. This step is easy anterosuperiorly but more difficult posteroinferiorly because of the presence of muscle insertions.



2

2

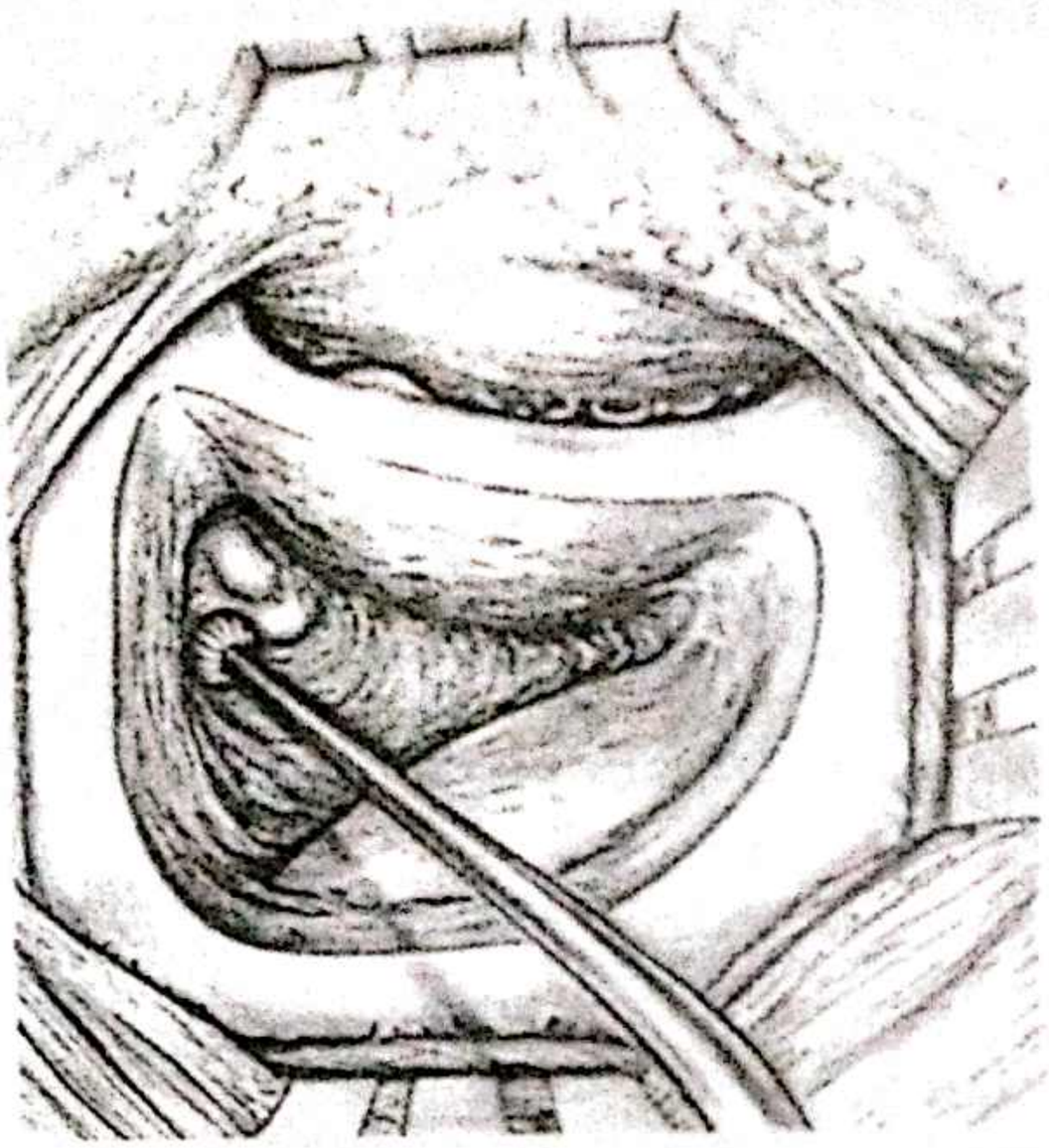
Two self-retaining retractors placed at right angles to each other permit exposure of the bone to be drilled.

The area of trepanation is shaped like a rectangle, bounded superiorly by the linea temporalis; anteriorly by the external auditory canal and the anterior part of the mastoid; inferiorly by a horizontal line separating the mastoid tip from the rest of the mastoid bone; and posteriorly by a vertical line situated 2–3 cm from the external auditory canal. The trepanation is often performed with an electric drill, although an air drill would be less traumatic to the inner ear. The mastoid air cell system is usually well-pneumatized in these patients (in the absence of any history of previous ear infections) and the trepanation is very easy. Using a large burr and sweeping strokes, the first landmark, the lateral sinus, is reached in the posterior part of the drilling area.

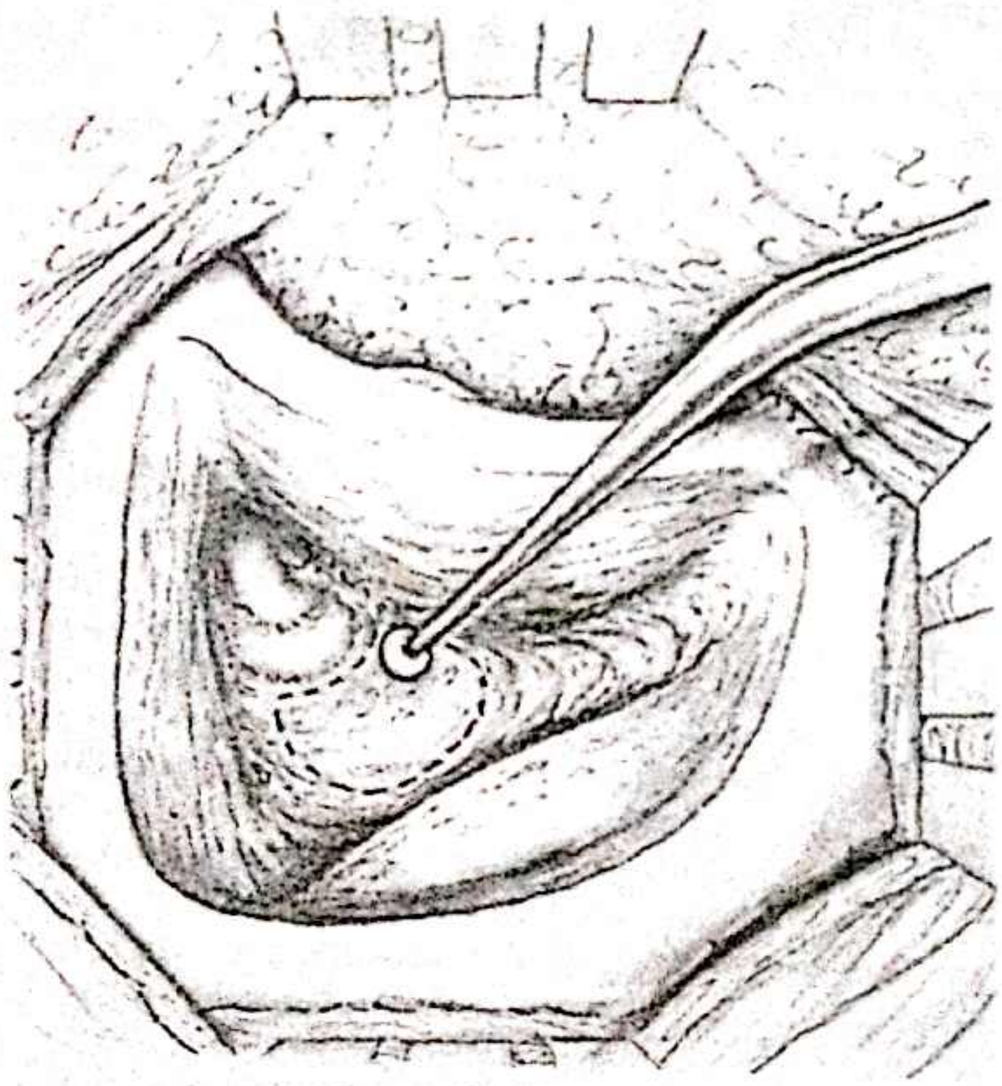
Once the lateral sinus is exposed, with its bony plate intact, the antrum is opened anteriorly. This constitutes the second landmark.

3

The antrum is enlarged, up to the lateral sinus posteriorly, the bony external auditory canal anteriorly and the aditus anterosuperiorly. Opening the aditus exposes the third landmark, the lateral semicircular canal. The posterior semicircular canal is exposed by drilling deeper and posterior to the lateral semicircular canal. Care must be taken not to open the posterior semicircular canal, as this would result in total deafness. With these landmarks established, major drilling in the mastoid is completed.



3



4

Exposure of the endolymphatic sac

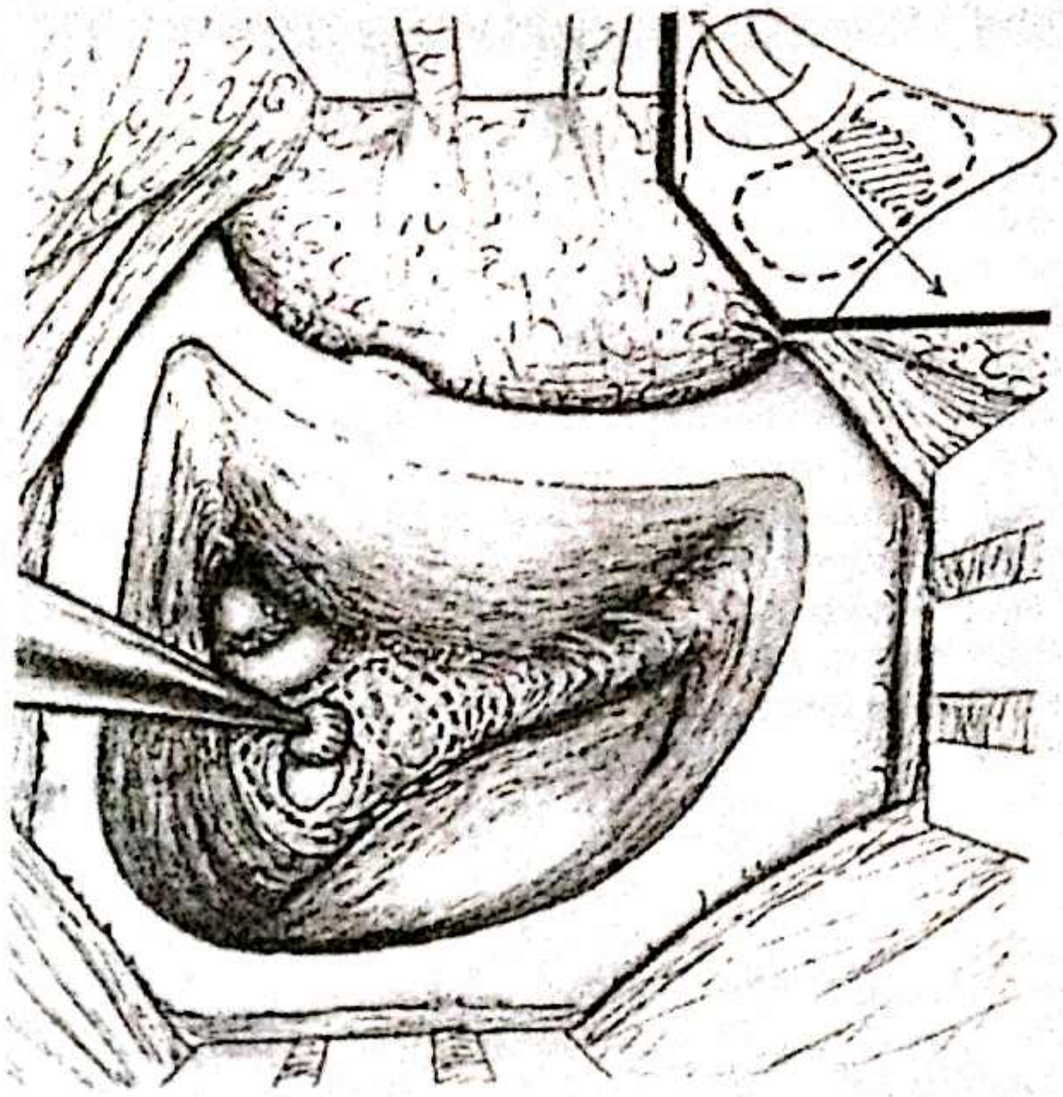
4

The endolymphatic sac is situated in front of the lateral sinus and behind the posterior semicircular canal. Its position corresponds to the anteroposterior axis of the lateral semicircular canal or, more often, a line immediately below this.

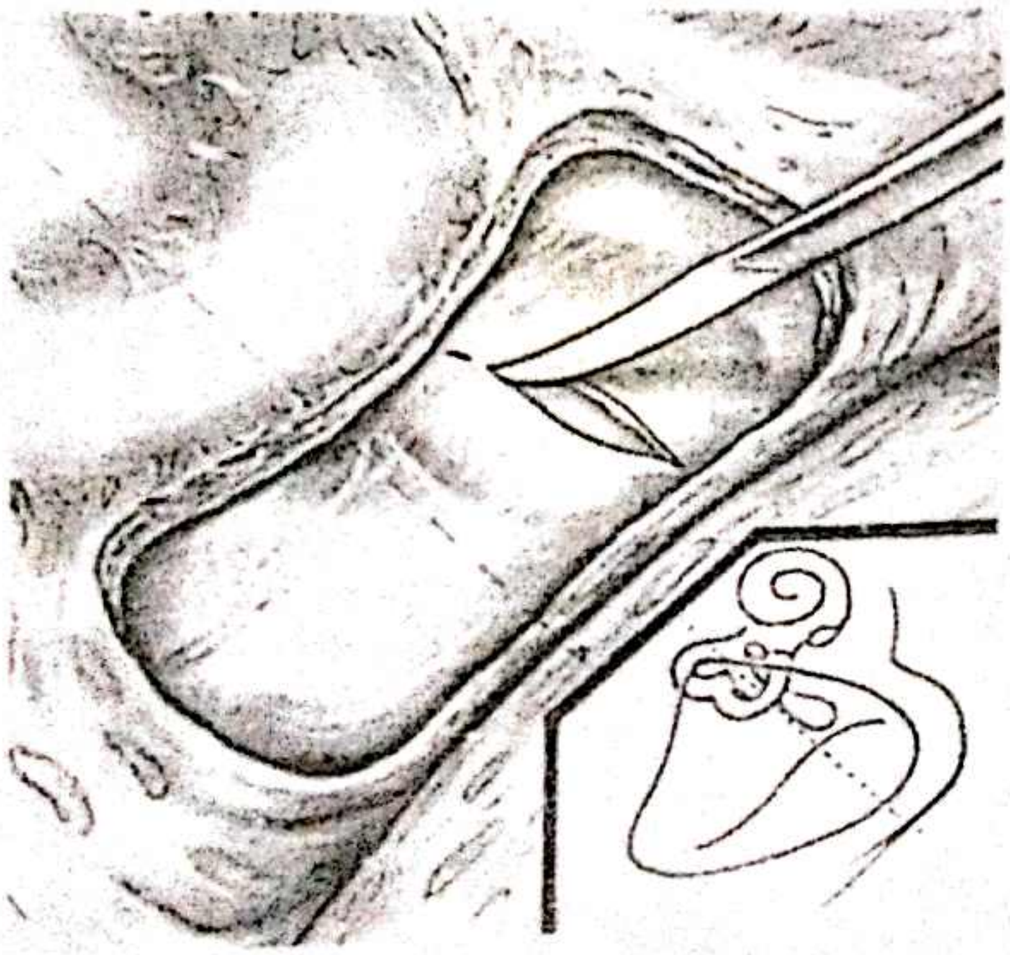
5

The bone in this area (2 cm high × 1 cm wide) is removed with a small cutting burr. When the cortex in the depth of the petrous bone is reached the cutting burr is replaced with a diamond burr and, using constant irrigation, the dura is exposed.

The sac is then exposed in the axis of the lateral semicircular canal or immediately below it. It appears slightly whiter than the rest of the dura, which is grey. The superior and inferior limits of the sac are outlined with a blunt instrument. It is important to remember that the dimensions of the sac can be extremely variable and that some patients have a very small sac immediately around the entrance of the endolymphatic duct. At times the sac is very difficult to locate.



5



6

6

Opening of the endolymphatic sac

Once exposed, the outer surface of the sac is incised from behind forward, using an ultra-fine scalpel blade (Beaver). Endolymph can now escape from the sac and from the duct in front of the incision. The opening is maintained by placing a fragment of Gelfoam in the incision. In the Portmann technique the inner wall of the endolymphatic sac is not opened, although this has been recommended by other authors, notably House, and Hasegawa and Naito.

7

Closure

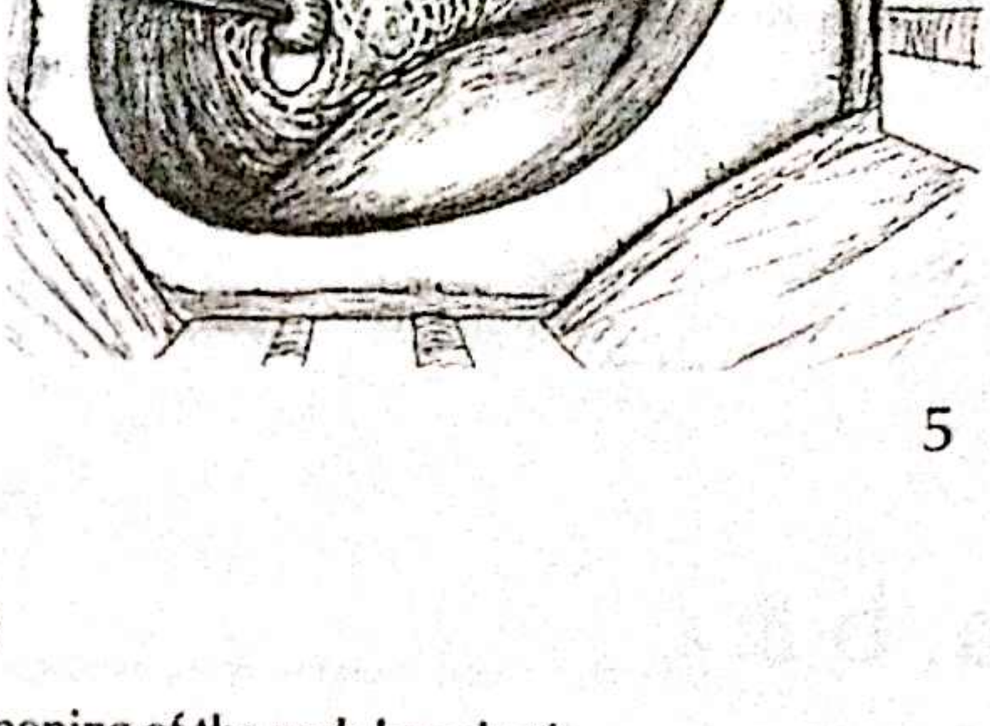
A large piece of absorbable Gelfoam is placed in the depth of the operative field. The wound is closed in two layers: a subcutaneous layer, using catgut, which perfectly replaces the periosteum over the opening caused by the trepanation; and a cutaneous layer in which a synthetic suture material (nylon) is used. If the haemostasis is not effective a drain is placed in the wound.

7

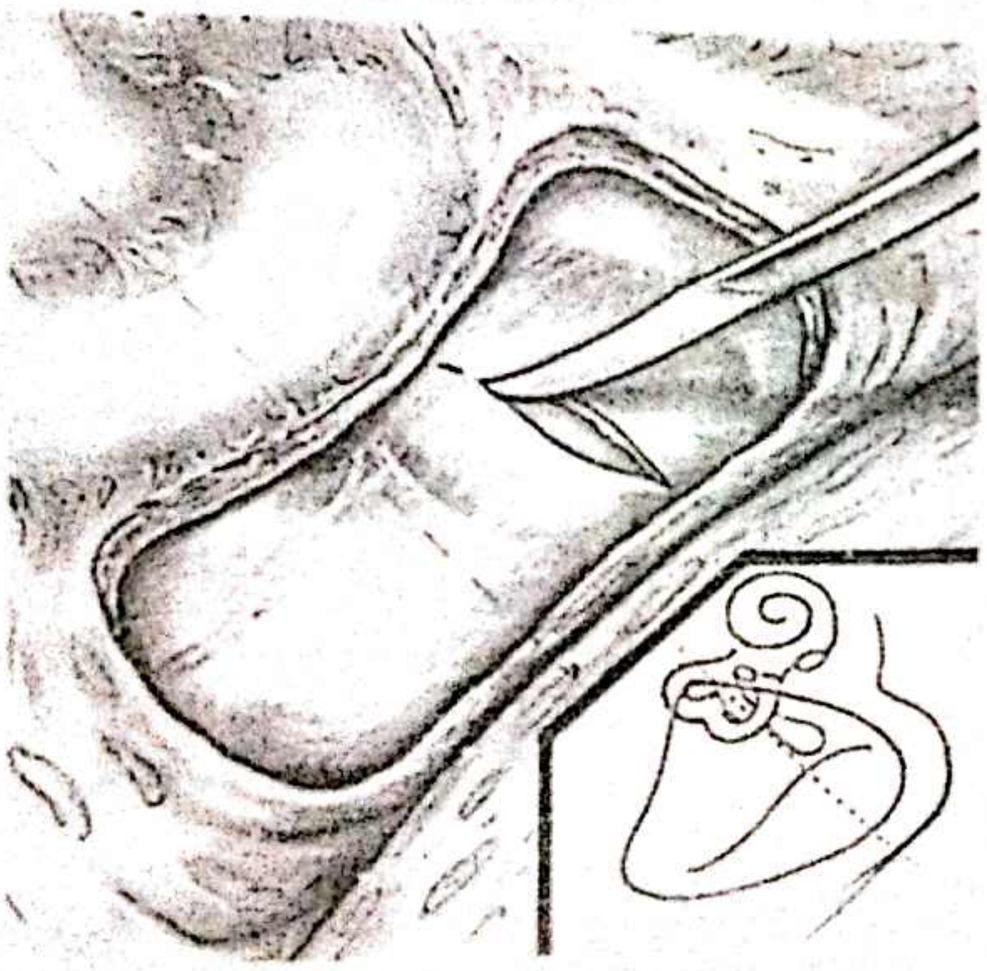
5

The bone in this area (2 cm high × 1 cm wide) is removed with a small cutting burr. When the cortex in the depth of the petrous bone is reached the cutting burr is replaced with a diamond burr and, using constant irrigation, the dura is exposed.

The sac is then exposed in the axis of the lateral semicircular canal or immediately below it. It appears slightly whiter than the rest of the dura, which is grey. The superior and inferior limits of the sac are outlined with a blunt instrument. It is important to remember that the dimensions of the sac can be extremely variable and that some patients have a very small sac immediately around the entrance of the endolymphatic duct. At times the sac is very difficult to locate.



5



6

6

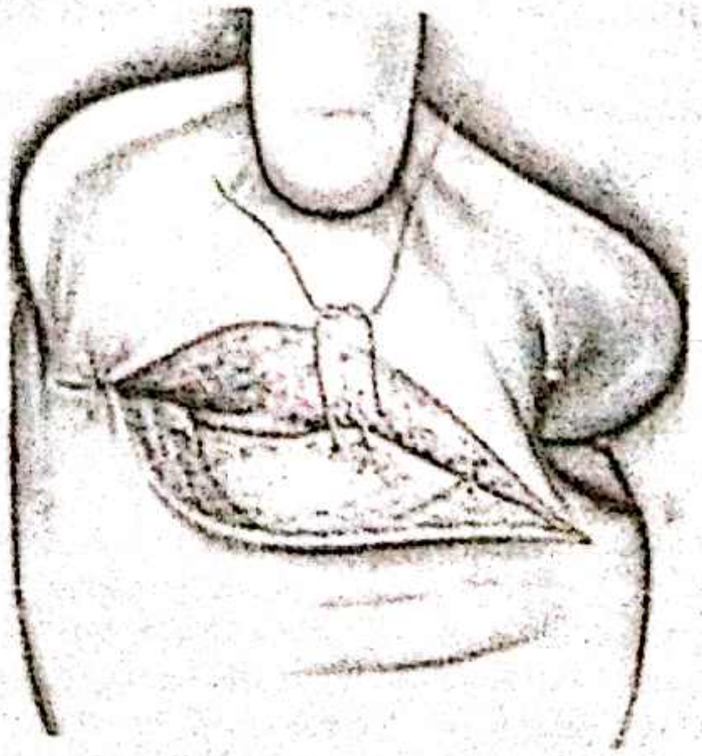
Opening of the endolymphatic sac

Once exposed, the outer surface of the sac is incised from behind forward, using an ultra-fine scalpel blade (Beaver). Endolymph can now escape from the sac and from the duct in front of the incision. The opening is maintained by placing a fragment of Gelfoam in the incision. In the Portmann technique the inner wall of the endolymphatic sac is not opened, although this has been recommended by other authors, notably House, and Hasegawa and Naito.

7

Closure

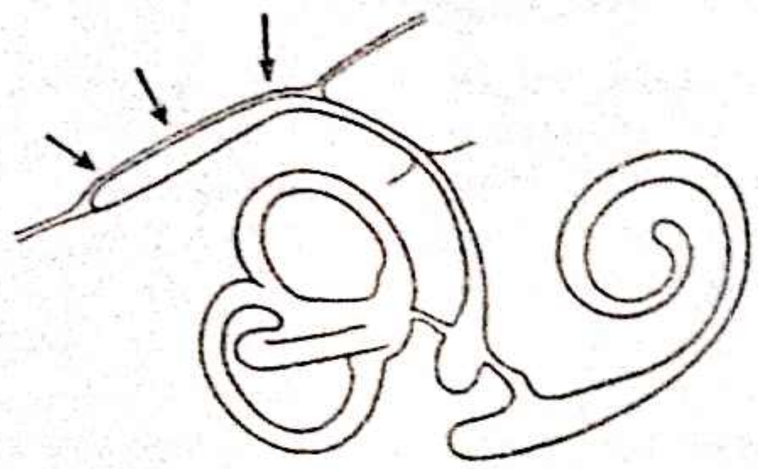
A large piece of absorbable Gelfoam is placed in the depth of the operative field. The wound is closed in two layers: a subcutaneous layer, using catgut, which perfectly replaces the periosteum over the opening caused by the trepanation, and a cutaneous layer in which a synthetic suture material (nylon) is used. If the haemostasis is not effective a drain is placed in the wound.



7

MODIFICATIONS OF THE PORTMANN TECHNIQUE

If opening of the endolymphatic sac is indeed the reason for the diminution of crises in Menière's disease, then it would be logical to modify the Portmann technique so as to ensure long-term patency of this opening. In the Portmann technique a scar forms over the opening in weeks or months. Several authors have searched for a procedure which would permit fistulization of the sac (House, and Hasegawa and Naito). Shambaugh has stressed that scarification of the incision does not affect long-term results. Our figures agree with this. Opening of the sac probably has two effects: (1) immediate decompression due to escape of endolymph from the sac; and (2) long-term decompression due to an as yet unknown factor.

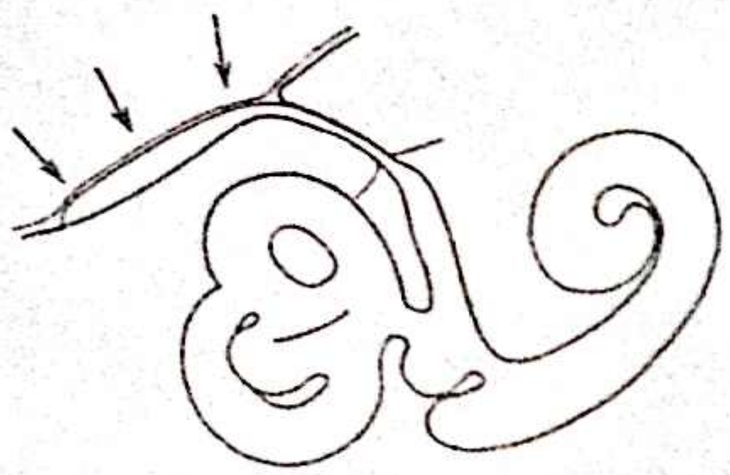


8a

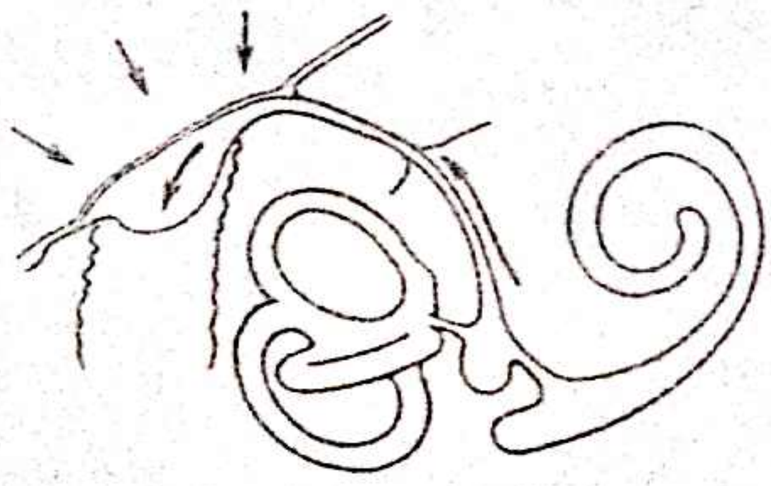
8a, b & c

The endolymphatic sac lies between the intracranial contents in the posterior cranial fossa and the posterior bony wall of the petrous bone (*a*). During a crisis of Menière's disease pressure in the sac increases but the sac is unable to dilate sufficiently to absorb this increase (*b*). Simple removal of the posterior bony wall permits the sac to expand to the exterior (*c*), thus eliminating the injurious effect of a crisis of endolymphatic hydrops. This mechanism explains why our long-term results are as good as those obtained by the modifications of House, and Hasegawa and Naito.

It appears absolutely unnecessary to open the subarachnoid space, as has been recommended by some authors. Moreover, it could result in intracranial complications if there is postoperative infection.



8b



8c

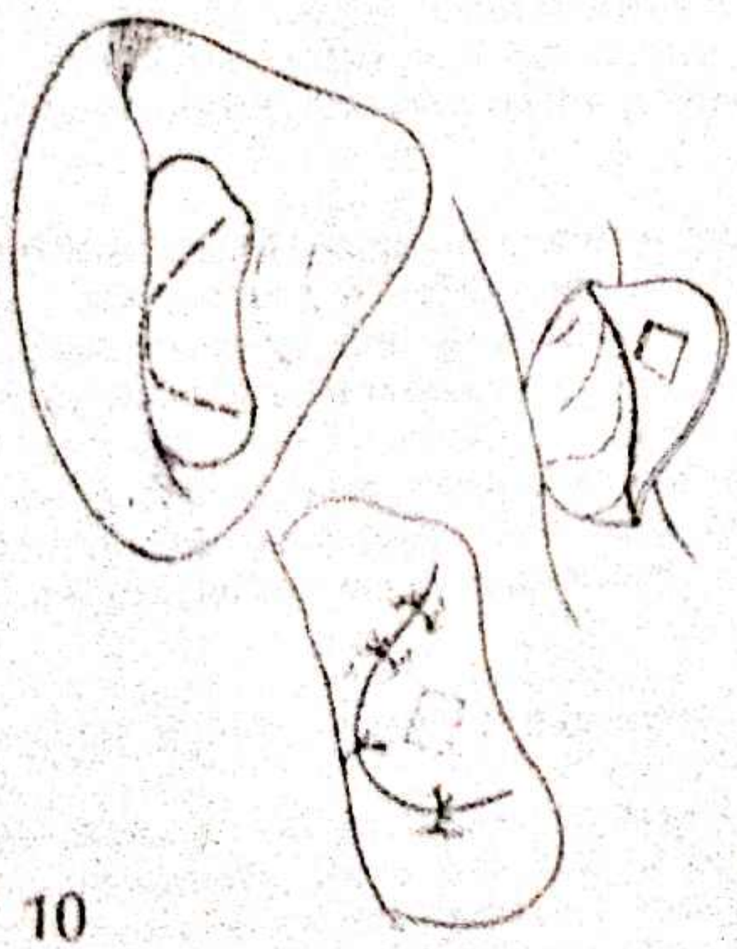
Modification by Shambaugh

Decompression can also be achieved without opening the sac. The technique is based on the observation that the exposed sac is ischaemic. A piece of temporalis muscle is therefore placed on the external surface of the sac to encourage revascularization.

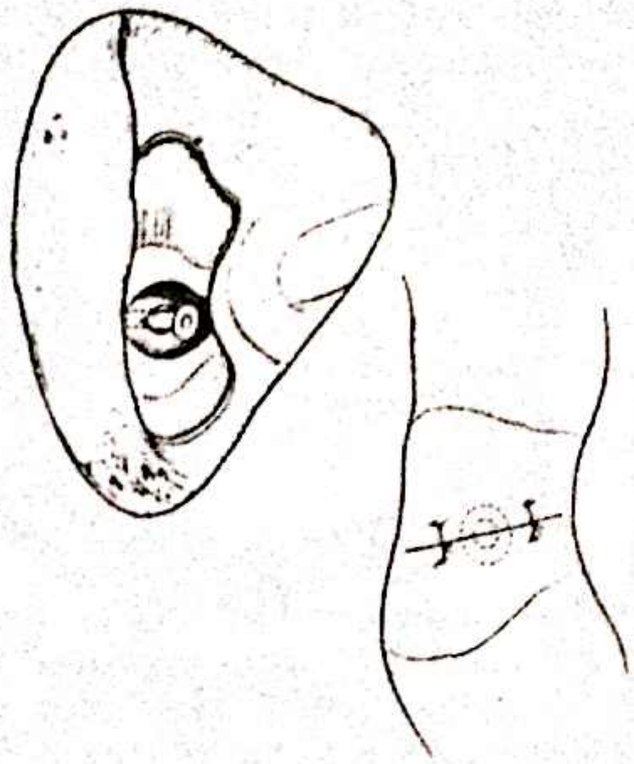
9

Modification by House (the shunt operation)

This is similar to the Portmann technique but differs on the following points. (1) After incision of the external wall of the sac the inner wall is incised, thus joining the endolymphatic sac to the subarachnoid space. (2) A small flanged Teflon tube is placed in this aperture. This ensures permanence of the communication between the endolymphatic sac and the subarachnoid space. (3) The external opening of the sac is closed with a suture. The surface is then covered with an absorbable substance (Gelfoam) or, even better, a piece of muscle filling the mastoid cavity. This plug prevents a cerebrospinal fluid fistula. The wound is closed as in the Portmann technique.



10



9

10

Modification by Hasegawa and Naito

The original approach used by Portmann is employed. The endolymphatic sac is exposed and an incision is made in the dura above, behind and below the sac. This flap is then reflected towards the anterior portion of the operative field, exposing the subarachnoid space, and the inner surface of the sac. The sac is opened to the interior by cutting a window in its inner surface. This creates a permanent fistula between the interior of the sac and the subarachnoid space. The flap is then returned to its original position and the dura is sutured behind, above and below. Gelfoam or muscle is used to fill the mastoid cavity, thus preventing a cerebrospinal fluid fistula. Closure of the wound is the same as in the other procedures.

Modification by Morrison

Morrison does not create a communication between the posterior fossa and the lumen of the sac, but prefers to place a short piece of polyethylene tubing into the sac and the end of the endolymphatic aqueduct to maintain drainage.

Modification by Arenberg

A valve similar to the unidirectional 'Krupin valve' used in ophthalmology for glaucoma, but adapted to the inner ear, is implanted into the sac. The external wall of the sac is closed by microsutures. The valve allows fluid to escape from the inside to the outside of the inner ear. Early results look very encouraging.

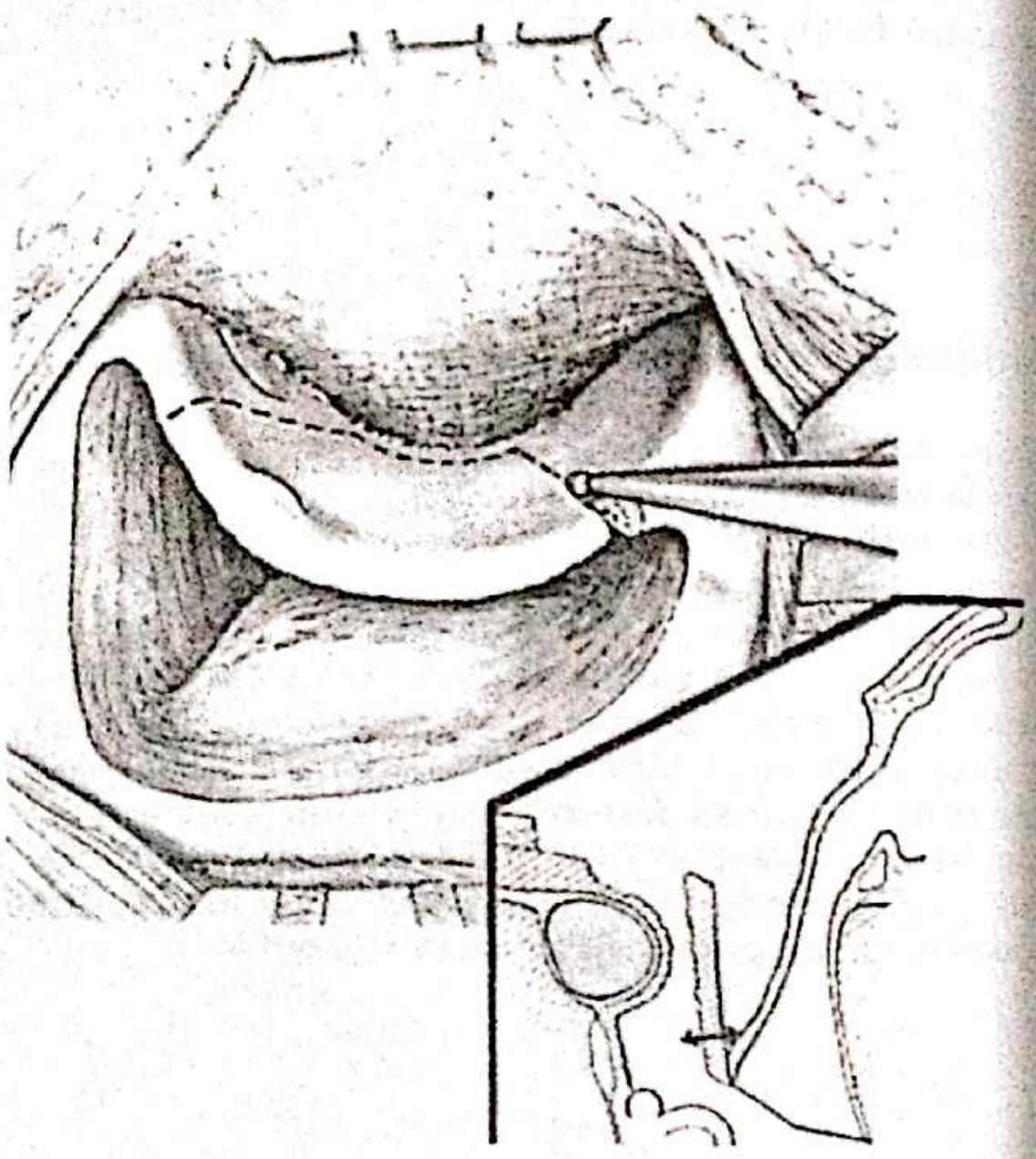
Operative complications

With adequate experience in microsurgery of the ear this is an absolutely straightforward procedure. There may, however, be some technical problems due to anatomical variations.

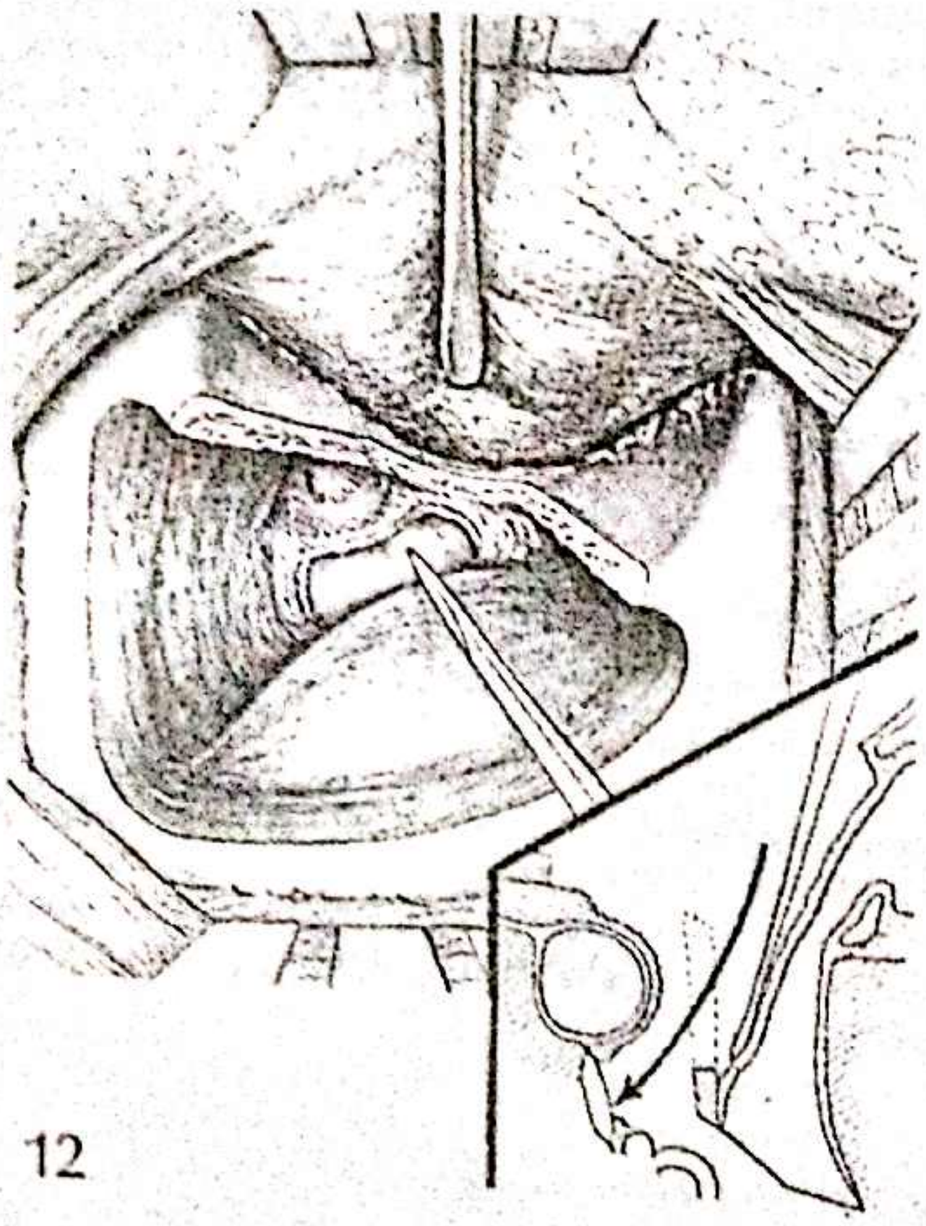
Difficult access to the endolymphatic sac

11

This problem may be encountered in sclerotic mastoids. The sac is in a frontal position, posterior to the protuberance of the lateral sinus. Even with oblique placement (visual axis anteroposterior) of the microscope, the external auditory canal blocks the area of the sac. Access may be improved by (*1*) complete exposure of the sigmoid sinus and its posterior retraction; or (2) partial temporary removal of the outer third of the external auditory canal with a very small burr. The bony fragment is put aside for later use.



11



12

12

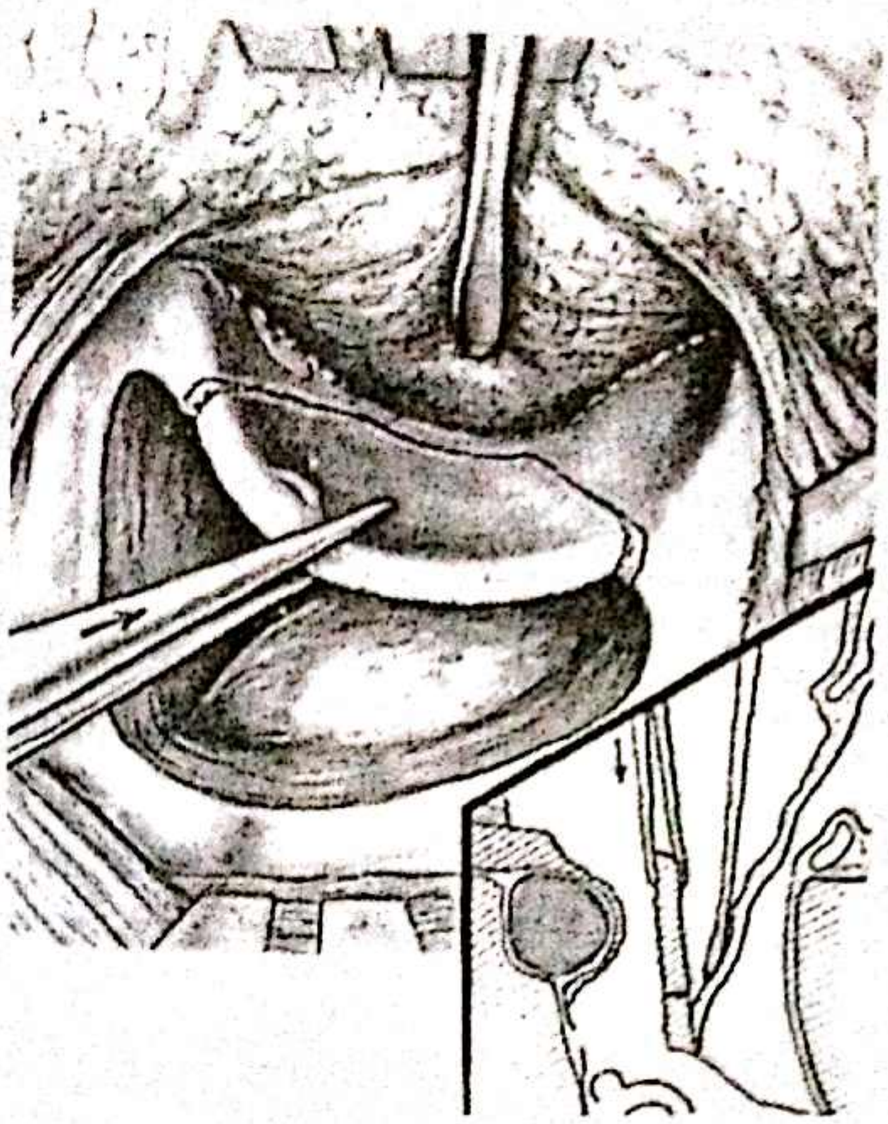
A soft tissue self-retaining retractor is used to provide the necessary visibility anteriorly. By placing the operating microscope more obliquely the presinus area of the endolymphatic sac can now be seen in the anteroposterior axis.

13

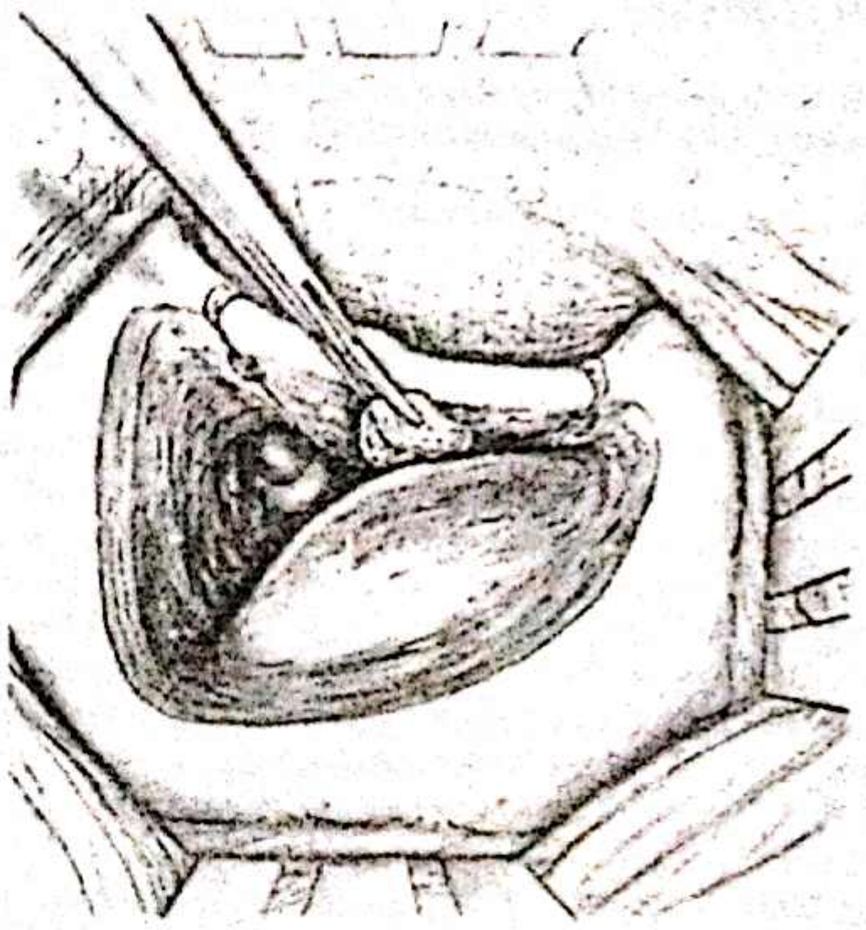
After completion of the decompression the canal is reconstructed by replacing the bony fragment as a free graft.

14

This is held in position by a drop of tissue adhesive (Histoacryl) or by a posterior graft of muscle or fascia.



13



14

Lack of space between the lateral sinus and the posterior semicircular canal

In some cases the space for the endolymphatic sac is extremely reduced. This is common in small mastoids even if the lateral sinus is not prominent. The lateral sinus is found projecting towards the posterior semicircular canal. In exposing the sac the smallest burr available must be used to avoid opening the posterior semicircular canal. This problem obviously complicates the procedure.

Opening of the lateral sinus

This can result from an error in drilling technique and causes extremely brisk venous bleeding. Rapid control of the bleeding is achieved by placing a substance such as Oxycel or Surgicel in the tear. Reinforcement with a piece of muscle may be necessary. Once the bleeding is controlled the procedure may be continued.

Opening of the posterior semicircular canal

If the lateral sinus is very prominent or the otic capsule placed very posteriorly, there is a risk of opening the posterior semicircular canal. This may result in total deafness and a 'dead' labyrinth. Suction should not be used in the open canal. The fistula is closed with a piece of conjunctiva. Since conservation of hearing is one of the purposes of this procedure it is important to avoid this complication. If there is a risk of opening the posterior semicircular canal the labyrinth should be destroyed by a more radical procedure.

Opening of the dura

This complication is unusual. It does not produce a serious problem. A silk suture is usually satisfactory to close the tear. If necessary the tear can be covered with a graft of temporalis fascia which is held in place by a plug of Gelfoam or muscle.

A persistent fistula could result in meningitis. This risk, though small, is real in the techniques used by House, and Hasegawa and Naito, in which the posterior fossa is opened routinely.

Postoperative care

The patient is given prophylactic antibiotics and anti-inflammatory agents because of the proximity of the dura and the lateral sinus. If the indications for surgery have been followed rigidly vertigo should disappear on the first day after surgery. The patient is instructed not to move his head suddenly or excessively. Bed rest is prescribed for the first 3 to 4 days postoperatively, and activities are slowly accelerated after 4 days. Vestibular exercises are given if there is postoperative vertigo. Skin sutures and packing in the external auditory canal are removed on the 8th postoperative day. The packing in the canal prevents postoperative stenosis (especially if the posterior bony wall was removed in order to attack the sac at an oblique angle). Audiometry and electronystagmography are carried out one week postoperatively. These tests are repeated in 6 months and finally 1 year after the procedure.

Further reading

Anson, B. J. Surgical anatomy of the endolymphatic sac and perilymphatic duct. Laryngoscope 1964; 74: 480

Anson B. J., Harper, D. *et al.* The vestibular system. Anatomic considerations. Archives of Otolaryngology 1967; 85: 497

Arenberg, K. Endolymphatic sac valve implant surgery. Laryngoscope 1979; 89 (7) Suppl. 17, part 2

Clemis, J. D., Shambaugh, G. E. Jr. Preliminary experiences with operations on the endolymphatic sac. Laryngoscope 1966; 76: 1029

House, W. F. Subarachnoid shunt for drainage of endolymphatic hydrops. A preliminary report. Laryngoscope 1962; 72: 713

House, W. F. Subarachnoid shunt for drainage of hydrops. A report of 63 cases. Archives of Otolaryngology 1964; 79: 338

Morrison, A. The surgery of vertigo: saccus drainage for idiopathic endolymphatic hydrops. Journal of Laryngology and Otology 1976; 90: 87–93

Naito, T. Notre experience de l'operation de G. Portmann (ouverture du sac endolymphatique dans la maladie de menière). Revue de Laryngologie, Otologie, Rhinologie 1962; 83: 643

Portmann, G. Le traitement chirurgical des vertiges par l'ouverture du sac endolymphatique. Paris: Presse Médicale, 1926

Portmann, G. Vertigo: surgical treatment by opening the saccus endolymphaticus. Archives of Otolaryngology 1927; 6: 309

Portmann, M. Decompressive opening of the endolymphatic sac. Archives of Otolaryngology 1964; 79: 328

Portmann, G. Surgical treatment of vertigo by opening of the saccus endolymphaticus. Archives of Otolaryngology 1969; 89: 809

Pulec, J. Menière's disease. Philadelphia: W. B. Saunders, 1968

Shambaugh, G. E. Jr. Surgery of the endolymphatic sac. Archives of Otolaryngology 1966; 83:305

Illustrations by Gillian Lee

Translabyrinthine approach to the internal auditory meatus and cerebellopontine angle

Andrew Morrison FRCS
Senior Surgeon, Ear, Nose, and Throat Department, The London Hospital, London, UK

Preoperative

Indications and advantages

The translabyrinthine approach to the internal meatus and cerebellopontine angle has been used increasingly over the past two decades for the removal of acoustic neuromas. Some other space-occupying lesions in this site, such as meningiomas, angiomas, facial or jugular neurinomas and a variety of much rarer tumours can also be managed via this route. Two extensions of the operation increase its versatility: (1) by dissecting and re-routing the facial nerve from the internal meatus to the stylomastoid foramen it is possible to drill out the cochlea and the bone anterior to the meatus, thus gaining access to the petrous apex, anterior parts of the cerebellopontine angle and the clivus for the management of developmental epidermoids, meningiomas in this site or even chordomas of the clivus; (2) by dividing the tentorium cerebelli the operation can be extended to the middle fossa, facilitating the removal of meningiomas arising from the tent or of trigeminal neurinomas which are likely to involve both the middle and posterior fossae.

Translabyrinthine cochleovestibular neurectomy is occasionally indicated in patients with advanced unilateral Menière's disease in the hope of giving some relief from tinnitus besides curing the vertigo, or for the same reasons if there is a 'dead ear' after stapedectomy, viral labyrinthitis or trauma. Such patients should be warned that there is a less than 50 per cent chance of relief from tinnitus and a small risk to the facial nerve.

Skull base fractures which have destroyed the function of the ear and caused complete and immediate facial paralysis require exploration when the patient is fit for surgery. The translabyrinthine operation allows exposure of the whole length of the facial nerve from the brainstem to the parotid for grafting or for re-routing and end-to-end anastomosis.

The choice of operation for the exposure and removal of acoustic and other tumours depends on the experience and hence preference of the surgeon(s). Dr William House and his colleagues of the Otologic Medical Group in Los Angeles have exploited the translabyrinthine technique with great success. Their extensive experience suggests that this approach has significant merit compared to the earlier, non-microscopic suboccipital operation. This is due mainly to the diminished morbidity and mortality and the greatly improved prospect of facial nerve preservation. Although microneurosurgery from behind the sigmoid sinus can give equally good results, there are other advantages to the translabyrinthine operation. The operative access is at the expense of bone rather than brain, and indeed in the case of small or even medium-sized tumours the cerebellum is seen but hardly touched, while in the case of large neuromas access to the brainstem in the region of the trigeminal nerve and tentorial hiatus is relatively short and direct compared to the suboccipital operation. It can be argued that the larger the tumour the greater the advantage of the translabyrinthine operation. Provided that sufficient bone is removed from the squamous temporal bone and the mastoid posterior to the sigmoid sinus, and that the tumour is gutted with a House-Urban rotary dissector or with the newer ultrasonic Cavitron, removal can be effected with

adequate access and minimal brain displacement. Furthermore, since the facial nerve is identified early in the procedure, the risk of accidental damage is reduced and, even if the nerve has to be divided for total tumour removal there is the possibility of a reasonable result with primary facial nerve repair. As mentioned above, the possibility of transcochlear or transtentorial extension is another advantage of this procedure.

Contraindications and disadvantages

This procedure should not be undertaken without the cooperation of a neurosurgeon or without the facilities of modern departments of neuroradiology and neurosurgery. Whereas it may be acceptable for the experienced otologist to carry out translabyrinthine cochleovestibular neurectomy or to remove smaller lesions on his own, the larger lesions of the cerebellopontine angle remain in the province of the neurosurgeon.

Translabyrinthine surgery is contraindicated if there is any inflammatory disease of the middle ear or mastoid, since the risk of meningitis would be unacceptable. Acoustic neuromas do occur from time to time in patients with chronic ear disease.

The translabyrinthine operation destroys hearing, whereas the retrosigmoid or suboccipital approach with drilling out of the posterior wall of the internal meatus offers the prospect of hearing preservation since these tumours almost always arise from the vestibular nerve. To preserve hearing yet achieve total tumour removal the neuroma must be small, preferably arising from Schwann cells about the porus, and there must be good hearing and discrimination preoperatively. However, even with such ideal conditions and the use of the Cavitron there is no guarantee of success. For this reason, a case can be made for observation of patients with bilateral acoustic tumours, or at least for attempting to preserve hearing in one ear.

A disadvantage of the translabyrinthine operation is the risk, though not peculiar to this approach, of postoperative cerebrospinal fluid leakage and rhinorrhoea via the Eustachian tube. This will be discussed under 'Complications'.

The time factor is sometimes considered a disadvantage although an experienced surgeon should be able to expose the tumour via the temporal bone almost as quickly as a neurosurgeon via the classical suboccipital route. However, following the translabyrinthine dissection the mastoid cavity has to be obliterated with fat and the dural opening reinforced, preferably with fascia, and this requires initial surgery on the patient's thigh or abdominal wall.

Preoperative

Investigation

The neuro-otological diagnosis of vestibular schwannoma and its differentiation from all the other space-occupying lesions in the meatus or angle is beyond the scope of this chapter. Suffice it to say that accurate assessment is essential before deciding which, if any, operation to employ.

Anaesthesia

General anaesthesia with endotracheal intubation and controlled ventilation is essential. The loss of spontaneous respiration as a vital sign is outweighed by the advantages of proper ventilation and reduced intracranial pressure. Continuous monitoring of intra-arterial blood pressure via an intra-arterial catheter, continuous electrocardiographic recording and pulse rate monitoring allow any sudden changes in these vital signs to be detected: they are reliable guides to any interference with the brainstem or its blood supply. Controlled hypotension may be required. If used, the blood pressure should have returned to normal levels and the field must be dry before closure. It is advisable to have two units of blood cross-matched, although this is not often required.

If intravenous mannitol is to be given on completion of the exposure – a helpful manoeuvre in managing large tumours – then an indwelling urinary catheter is necessary. For larger tumours a ventricular catheter inserted into the ipsilateral frontal horn via a parietal burr hole and allowed to drain at the time of opening the posterior fossa also reduces intracranial pressure quite rapidly and significantly widens the exposure. For smaller lesions some neurosurgeons prefer to make a parietal burr hole to be prepared for any perioperative eventuality.

Position of patient

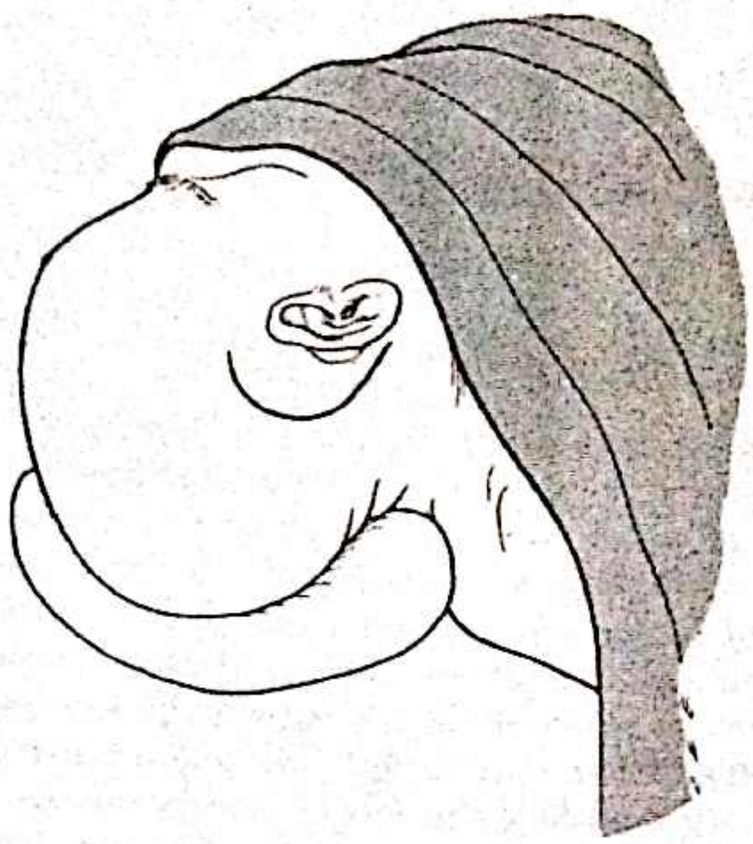
The patient is placed in the supine position with the head rotated to the opposite side and supported on a ring (see *Illustration 1*). Lateral table tilt is preferable to forced rotation of the head, which may increase venous and intracranial pressure. As mentioned above, the operation commences by taking a sheet of fascia lata and fat from the thigh, or fat from the abdominal wall. In the management of large neuromas it is advisable for the neurosurgeon to have made an ipsilateral parietal burr hole and to have inserted a ventricular drain.

the operation

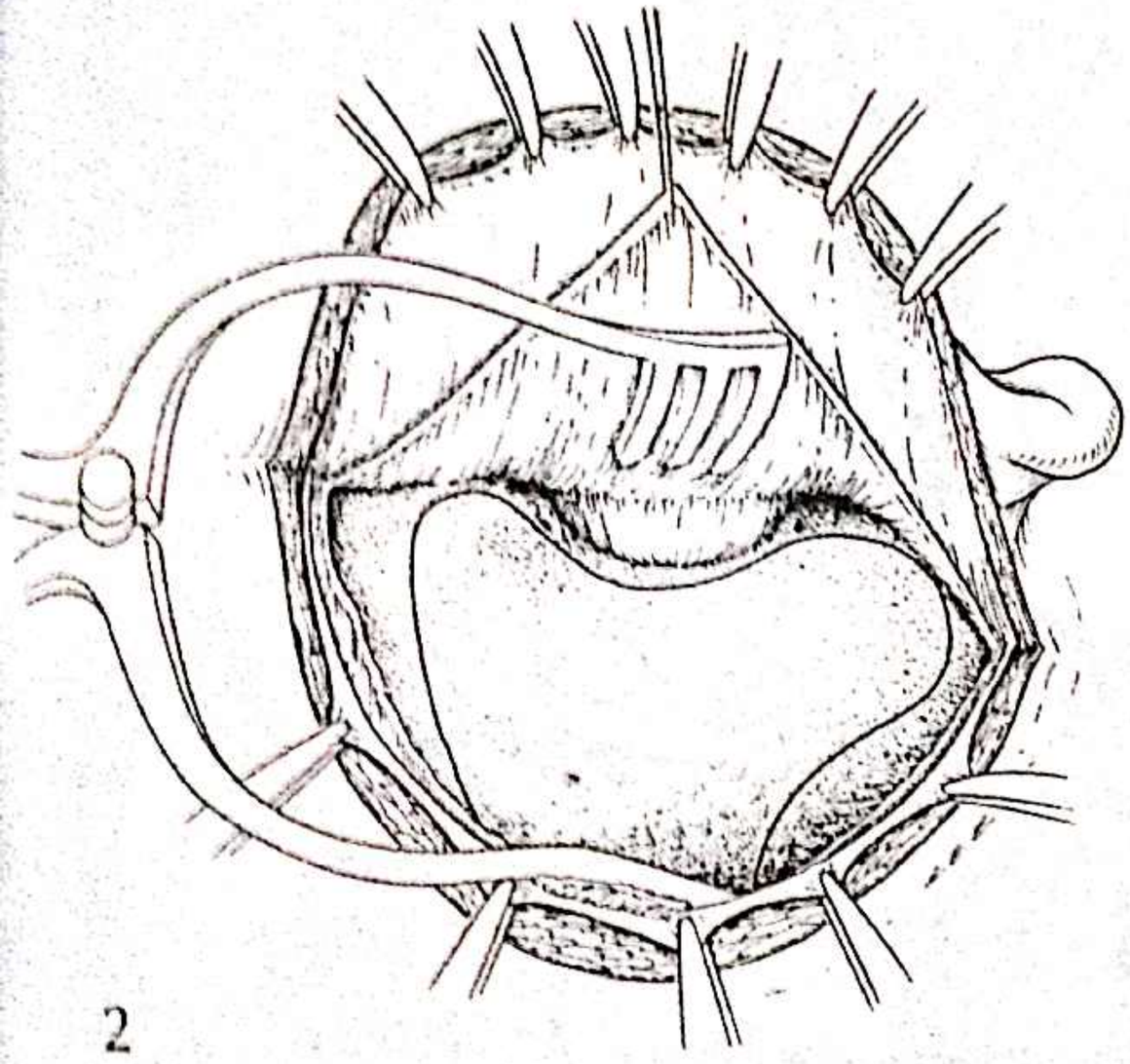
the incision

1

An incision is made parallel to the posterior aspect of the pinna, starting at the mastoid tip and reaching a point on the lateral aspect of the scalp three fingers' breadth above the tip of the pinna.



1



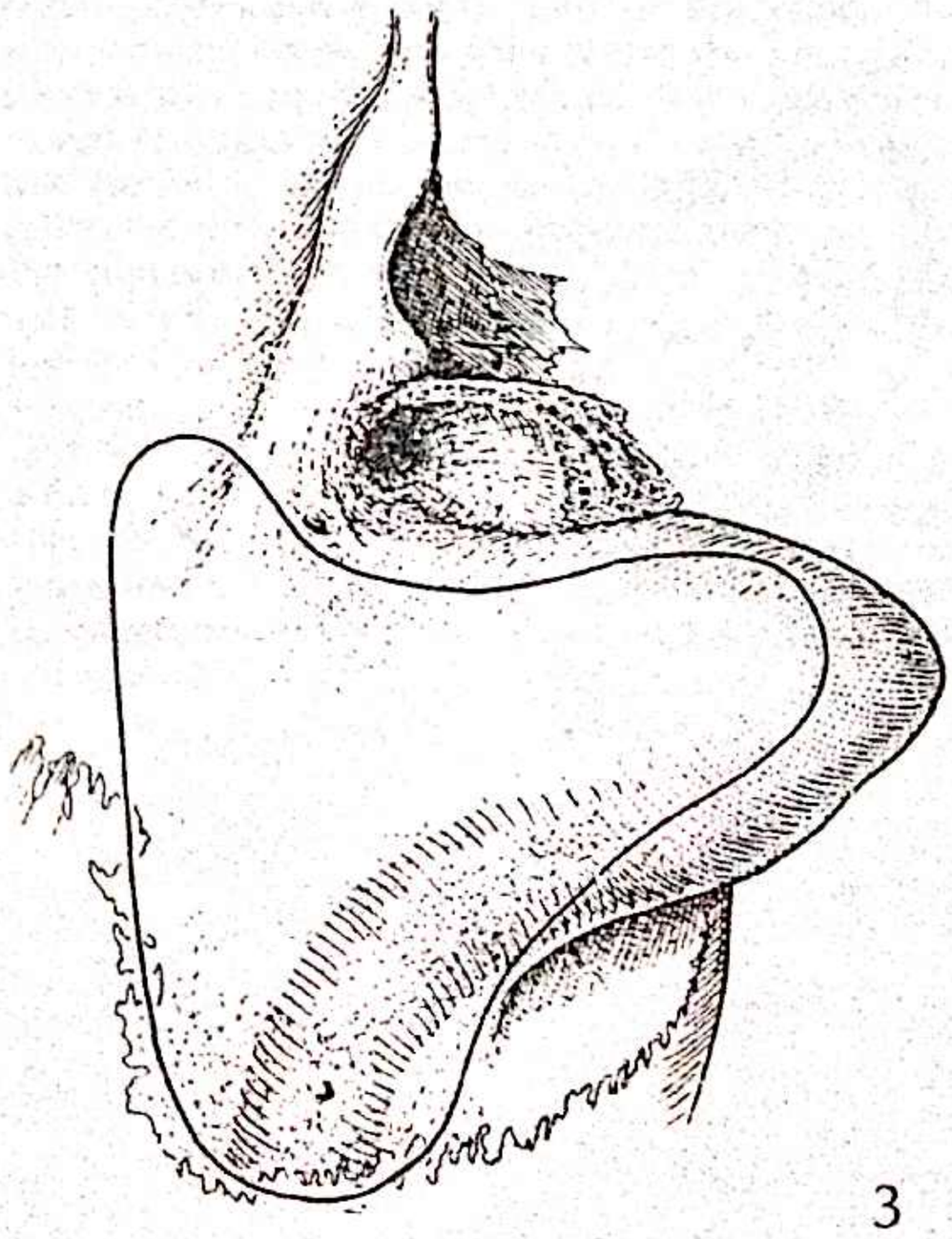
2

2

The skin flap is turned forward and haemostasis secured. A cutting diathermy incision is then made through the lower exposed part of temporalis fascia and muscle and the mastoid periosteum, and the musculo-periosteal flap is elevated. A self-retaining retractor is applied. Adequate bony exposure is essential and must include the lower part of the squamous temporal bone, the outer end of the bony external meatus and the mastoid bone posteriorly to its suture with the occipital bone.

3

The area of cortical bone to be removed (shown in outline) must extend upwards over the squamous temporal bone and posteriorly so that the whole of the sigmoid sinus, including the petrosal angle, may be uncapped.

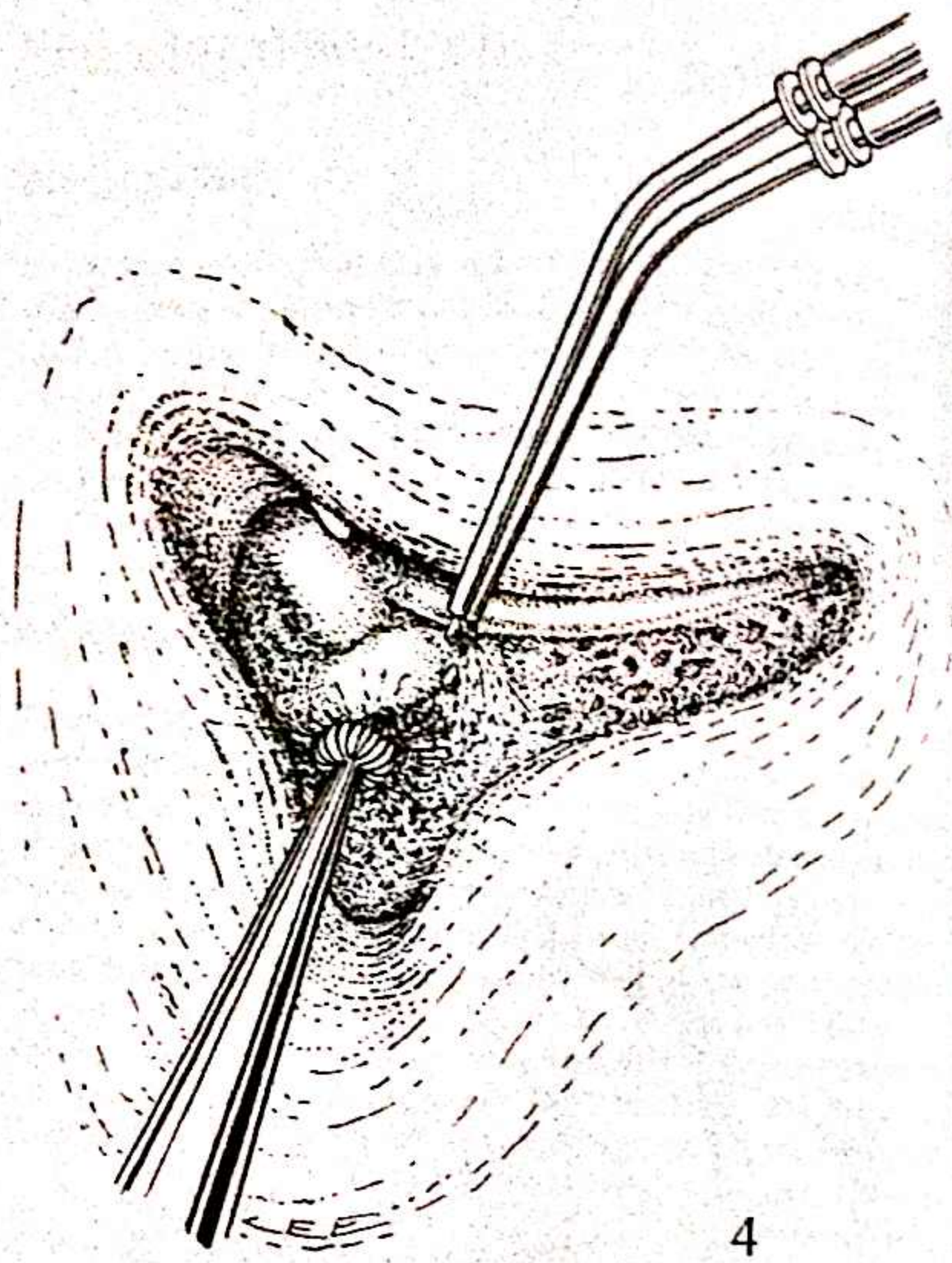


3

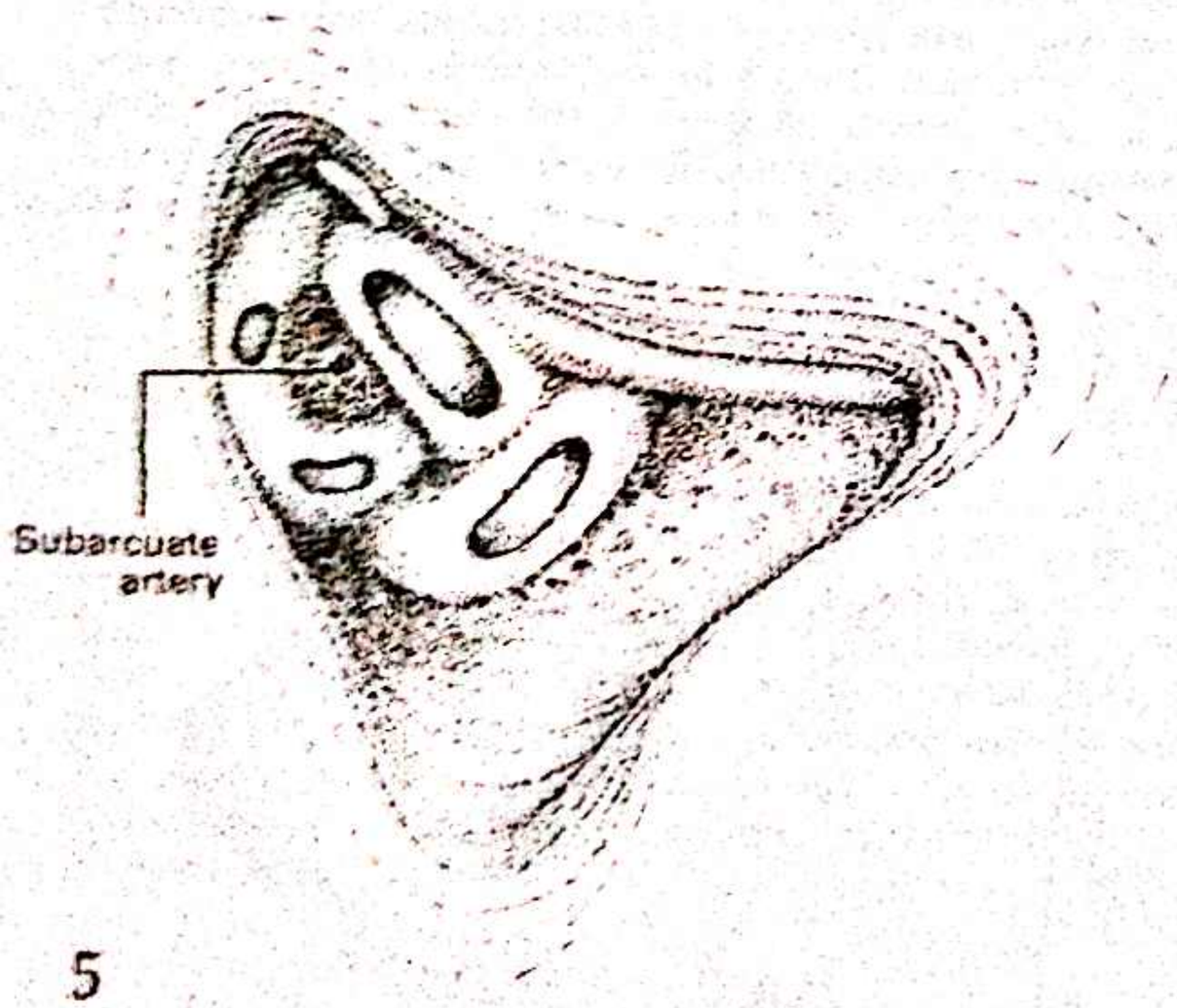
Cortical mastoidectomy

4

An extensive cortical mastoidectomy is then performed with a drill and cutting burrs. This part of the operation can usually be done with the naked eye. The posterior meatal wall is thinned but left intact, and the aditus is opened to obtain a view of the incus and possibly the malleus head. The sigmoid sinus, middle fossa and superior petrosal sinus angle are identified, leaving thin bone to protect these structures. The dense bone of the otic capsule surrounding the lateral and posterior semicircular canals is demonstrated. Continuous suction-irrigation aids and speeds up the dissection. Some surgeons advise exposing the descending portion of the facial nerve as shown, others prefer to avoid it. A detailed knowledge of the local anatomy is essential for this surgery.



4



5

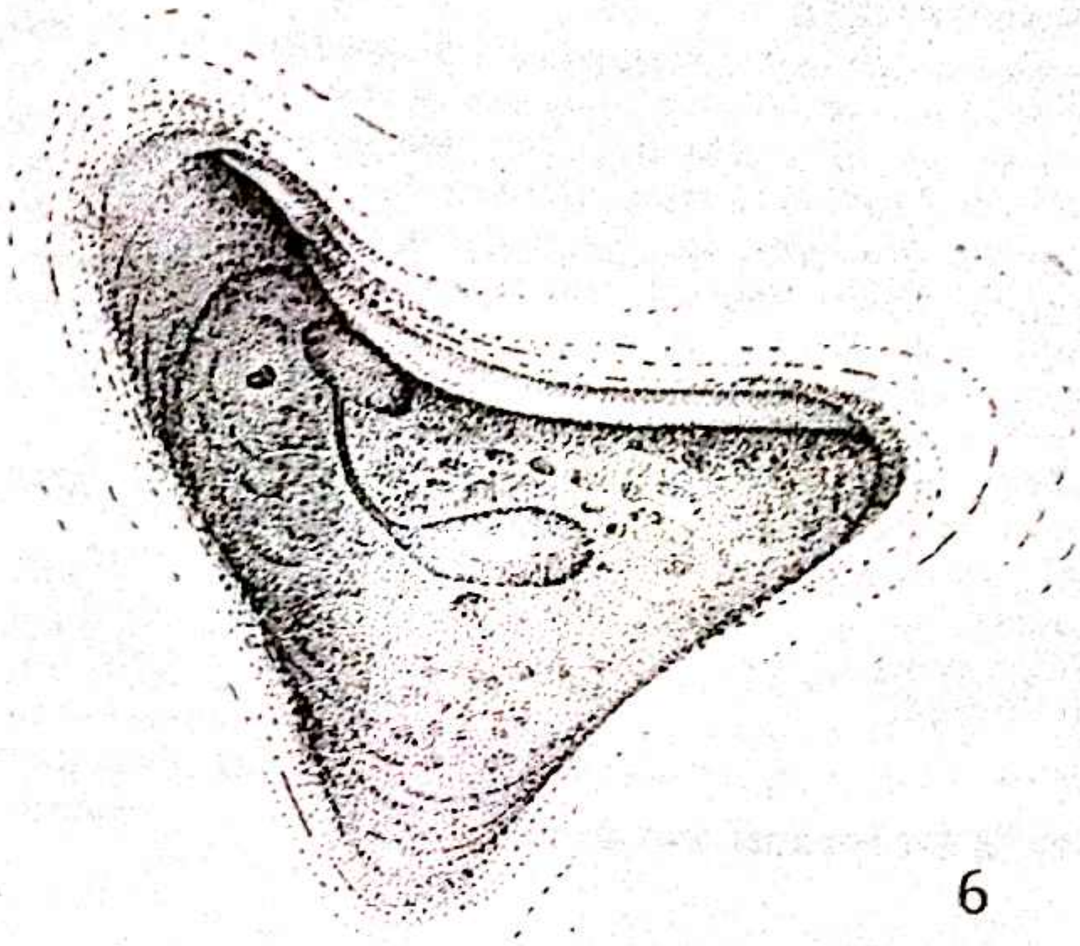
Labyrinthectomy

5

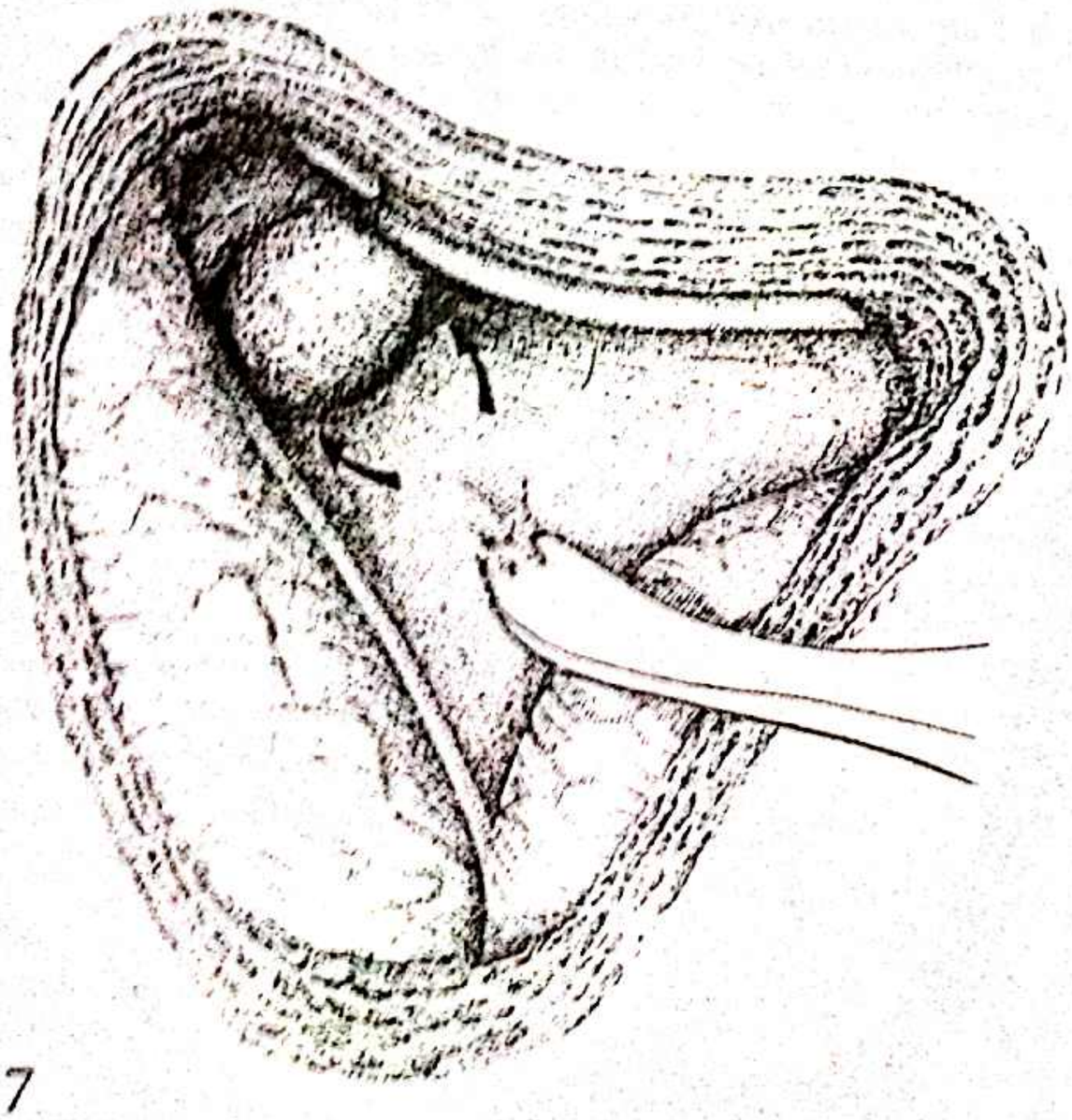
The operating microscope is introduced and used henceforth. The three semicircular canals are excised with small cutting burrs. It is customary to start with the lateral canal, using this as a superior anatomical landmark for the horizontal portion of the facial nerve, which remains supported by a thin shelf of bone. Care must be taken not to damage the nerve, which lies infero-medial to the ampullated end of the lateral canal. When dissecting out the posterior canal it should be noted that the ampullated end as it enters the vestibule lies deep or medial to the facial nerve. This area is most readily dissected when the middle fossa plate has been thinned and the line of vision can be rotated so that it can be viewed more from above. For removal of the superior canal a more upward direction of surgical access is required to avoid damage to the downward bulging of the middle fossa dura. The subarcuate artery, which traverses the arc of the superior canal, is a very consistent and useful reference point. Bleeding from it can be controlled with a small diamond burr.

6

When the canals and common crus have been drilled out, the vestibule and its contents are clearly visible. Removal of the utricle and saccule leaves the superior vestibular nerve protruding through the thin bone which separates the lateral end of the internal auditory meatus. The white linear streak in the form of an inverted 'J', commencing at the medial border of the common crus, is the aqueduct of the vestibule. This is drilled out and followed inferiorly, exposing the whole of the endolymphatic sac in the posterior fossa dura. Removal of bone for 3–4 mm antero-medial to the sac delineates the extent of the exposure in this direction.



6



7

Exposure of internal meatus

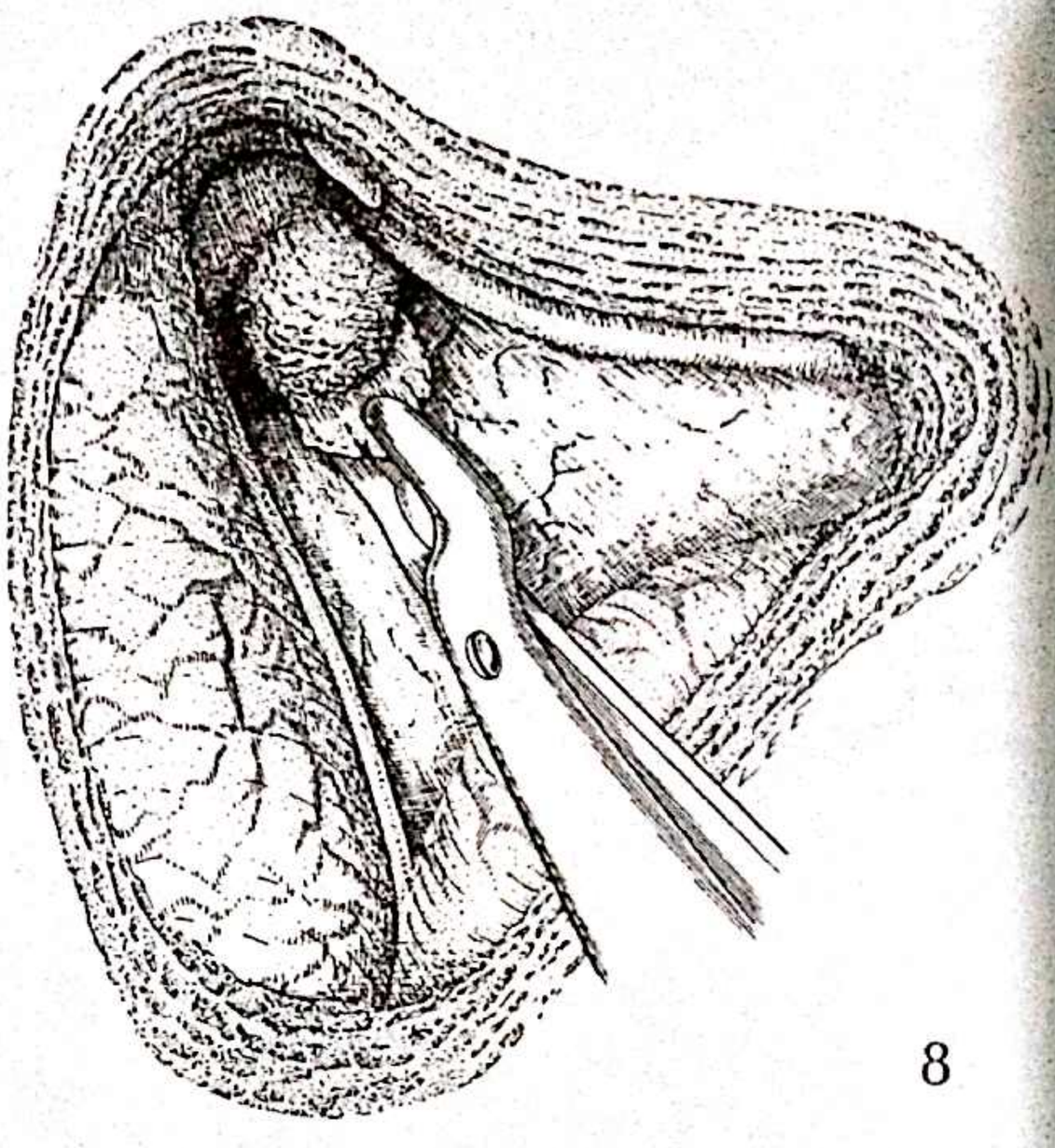
7

There are few landmarks for the remainder of the bony dissection, which involves exposure of the superior, posterior and inferior margins of the whole length of the internal meatus. The vestibule and superior vestibular nerve delineate the lateral end of the canal. In well-pneumatized bones cells lying above the internal meatus simplify this part of the operation. The subarcuate artery passes through the posterior fossa dura above and behind the posterior lip of the porus (left arrow), and the posterior fossa dura can be followed antero-medially from the sigmoid sinus to the porus. When drilling postero-inferiorly to the medial end of the porus (right arrow), the jugular bulb may come into view; sometimes this is high, making the dissection more difficult. A variety of cutting and diamond burrs are used to complete the dissection, which should leave thin bone overlying the posterior fossa dura and sigmoid sinus posteriorly, the superior petrosal sinus and middle fossa dura superiorly, the jugular bulb inferiorly and the internal meatus antero-medially.

Exposure of dura

8

The bone dissection is completed by removing the paper-thin bone with suitable elevators, curettes and forceps. The extent of dural exposure depends on the indication for surgery and, in the case of tumours, on the size of the lesion. Access to the cerebellopontine angle is simplified and widened by removing bone over the sigmoid sinus and squamous temporal bone. Dural vessels are coagulated with bipolar endothermy. When managing large acoustic neuromas this is the stage when the intravenous mannitol will be given and the ventricular drain opened.



8

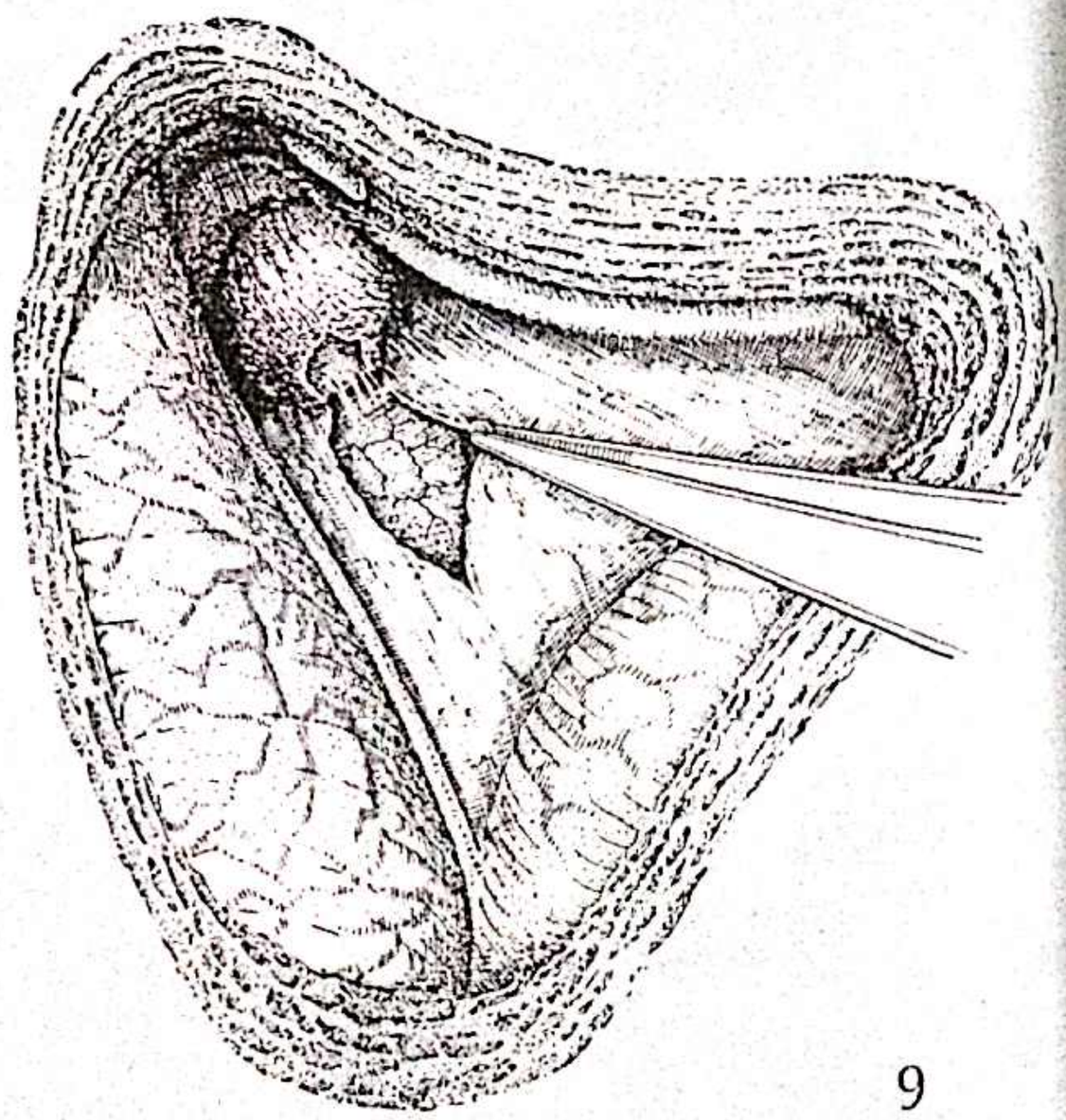
Opening the meatus and angle

9

The dura of the posterior fossa and internal meatus is then opened with scissors. Vessels are coagulated as necessary. Over the cerebellum the dura and arachnoid appear as two very distinct layers. Opening of the arachnoid causes a flow of cerebrospinal fluid unless the tumour is large and fills the whole of this area. In the case of small tumours, or if cochleo-vestibular neurectomy is being performed, the loop of the anterior inferior cerebellar artery may protrude through the dural opening behind the porus and on a deeper plane the petrosal vein will be seen passing above the tumour or the neurovascular bundle.

The great majority of schwannomas arise from the superior vestibular nerve, and some from the inferior portion. The facial and cochlear nerves normally lie anterior to the tumour and are initially obscured by it. However, sometimes the facial nerve lies above the tumour and rarely on its posterior surface, where it is at considerable risk even if identified. If the tumour has arisen more medially, even if it fills the canal in the usual way, the superior vestibular nerve may be identified in this same area. The intrapetrous portion of the facial nerve, which lies between the lateral end of the internal meatus and the geniculate ganglion, may be exposed with diamond burrs. The wedge of bone found between the facial and superior vestibular nerves in this area is known as Bill's bar.

Further dissection depends on the underlying pathology. Acoustic neuroma removal is described in the 'Neurosurgery' volume[1]. The procedure requires continuous suction-irrigation, the use of neurosurgical patties, sharp as opposed to blunt dissection and control of bleeding with bipolar endothermy. A facial nerve stimulator may be helpful.



9

Closure

Haemorrhage must be controlled before closure and the operative site should be watched for 20 to 30 minutes after allowing the blood pressure to return to normal. The aditus is packed with muscle around the incus and head of malleus, and a square of fascia laid across. The dural flaps are approximated, a large sheet of dura is invaginated to cover the dural defect and the mastoid cavity is filled with fat. Tissue glue may be used. The pericranial flaps are then closed over the fat and the scalp is closed in two layers without drainage.

Postoperative care

The patient should be woken soon after completion of the surgery so that spontaneous neurological functions may be observed and recorded.

Neurosurgical nursing is essential for the first 48 hours. The patient is nursed in the semi-sitting position. Antibiotics and steroids are given for five to six days. If there is facial paralysis the eye should be protected by a shield. If the facial nerve has been divided a lateral tarsorrhaphy may be necessary. The majority of patients make an uneventful recovery and may leave hospital after about ten days, when the thigh sutures have been removed.

Complications

Facial paralysis

Partial or delayed postoperative facial paralysis is likely to recover to a large extent, if not completely. If the nerve is known to be intact yet there is a complete postoperative paralysis it is usually worth waiting at least six to nine months. Artificial tear fluid, antibiotic eye drops, partial tarsorrhaphy and the use of shielding have all been found helpful in such patients. If the nerve is known to have been divided and primary repair has been impossible, a facio-hypoglossal anastomosis is done about ten days postoperatively.

Cerebrospinal fluid leak and rhinorrhoea

Both cerebrospinal rhinorrhoea and CSF leakage through the wound may occur in the immediate postoperative period, while the former may also develop up to several weeks later. The immediate problem may settle with a few days of spinal drainage or with repeated lumbar punctures. Even with most careful sealing of the aditus and free grafting of the operative site, cerebrospinal rhinorrhoea remains the most frequent and troublesome complication of the translabyrinthine operation, occurring in at least 1 in 20 cases. Reopening and replacement of the grafts normally effects a seal. If this becomes necessary it is wise to use a spinal drain for a few days. Late-onset rhinorrhoea may present as such or may be indicated by the development of meningitis.

Leptomeningitis

This is a rare but possible immediate complication. If systemic steroids are being used together with antibiotics, the signs of meningitis may be minimal and examination of the cerebrospinal fluid may be the only way to make the diagnosis. Lumbar puncture should be done in cases of doubt.

Haematoma

Haematoma formation in the tumour cavity is a serious development, but fortunately very unusual. Unless diagnosed and evacuated without delay it can be fatal or result in brainstem ischaemia.

Deep venous thrombosis

The seriousness of a postoperative bleed into the angle is such that perioperative heparin therapy is contraindicated, even though there is some risk of deep vein thrombosis with such a prolonged operation. Early mobilization and special stockings help to avoid this complication.

Reference

1. King, T. T. and Harrison, A. W. Translabyrinthe and transtentorial removal of acoustic nerve tumour. In: Operative Surgery: Neurosurgery, 3rd Edn. Lindsay Symon, (Consultant Ed) P. 214–224. London: Butterworths, 1979

Illustrations by Gillian Lee

Transmeatal cochleovestibular neurectomy

E. Garcia-Ibañez MD
Otologic Institute, Barcelona, Spain

F. Alvarez de Cozar MD
Chief, Ear, Nose and Throat Department, Centro Ramon y Cajal, Madrid, Spain

Introduction

There are five recognized surgical approaches for section of the eighth cranial nerve. Cochleovestibular neurectomy may be performed either near the brainstem by the retrolabyrinthine or retrosigmoid route, or in the internal auditory canal by the middle fossa, translabyrinthine or transmeatal approach. The method of choice depends on the clinical indication and the experience and preference of the surgeon. In the presence of an infected ear or mastoid, for example, only the retrosigmoid operation would be appropriate.

Cochleovestibular neurectomy may be indicated in advanced unilateral Menière's disease with very poor hearing and continuing symptoms, in some patients with a 'dead ear', troublesome tinnitus and/or vestibular symptoms after failed stapedectomy, and in patients with similar symptoms after sudden idiopathic loss of inner ear function.

The transmeatal operation has the advantage of being the most direct anatomical route to the internal auditory canal and, for those familiar with it, one of the quickest of such operations. It has the disadvantage, common to most of the other approaches, of possible cerebrospinal fluid (CSF) leak, meningitis or damage to the facial nerve.

Preoperative

Preparation of patient

Before the patient comes to theatre it is advisable to have shaved 4 to 6 cm around the ear, to have removed any wax or debris from the ear canal and to have ensured that there is no local skin sepsis. The skin preparation in theatre is a matter for the surgeon's preference. Antibiotic cover is advisable.

Anaesthesia

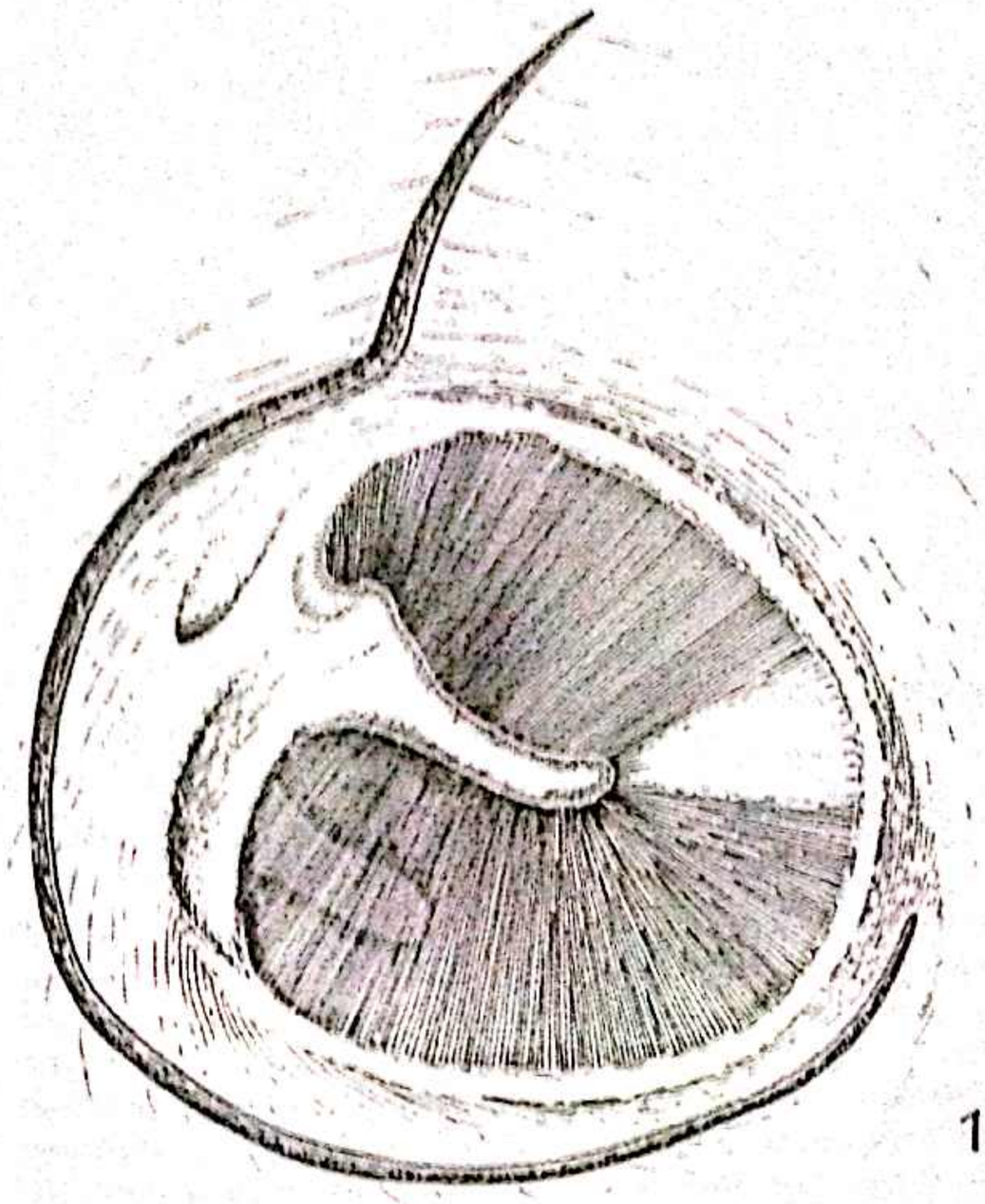
The operation is carried out under general anaesthesia with endotracheal intubation. If controlled hypotension is to be used the preoperative assessment should include a full blood count to exclude any anaemia and a chest X-ray and ECG to help exclude coronary or cardiac disease. Normally, a combination of local and general anaesthesia should be adequate.

The operation

The incision

1

An endural incision is enlarged 2 cm superiorly over the temporalis muscle and fascia. Fascia is taken for subsequent reinforcement of the tympanic membrane and muscle is taken for obliteration and sealing of the opening made into the internal canal. Self-retaining retractors are used to improve the operative access.

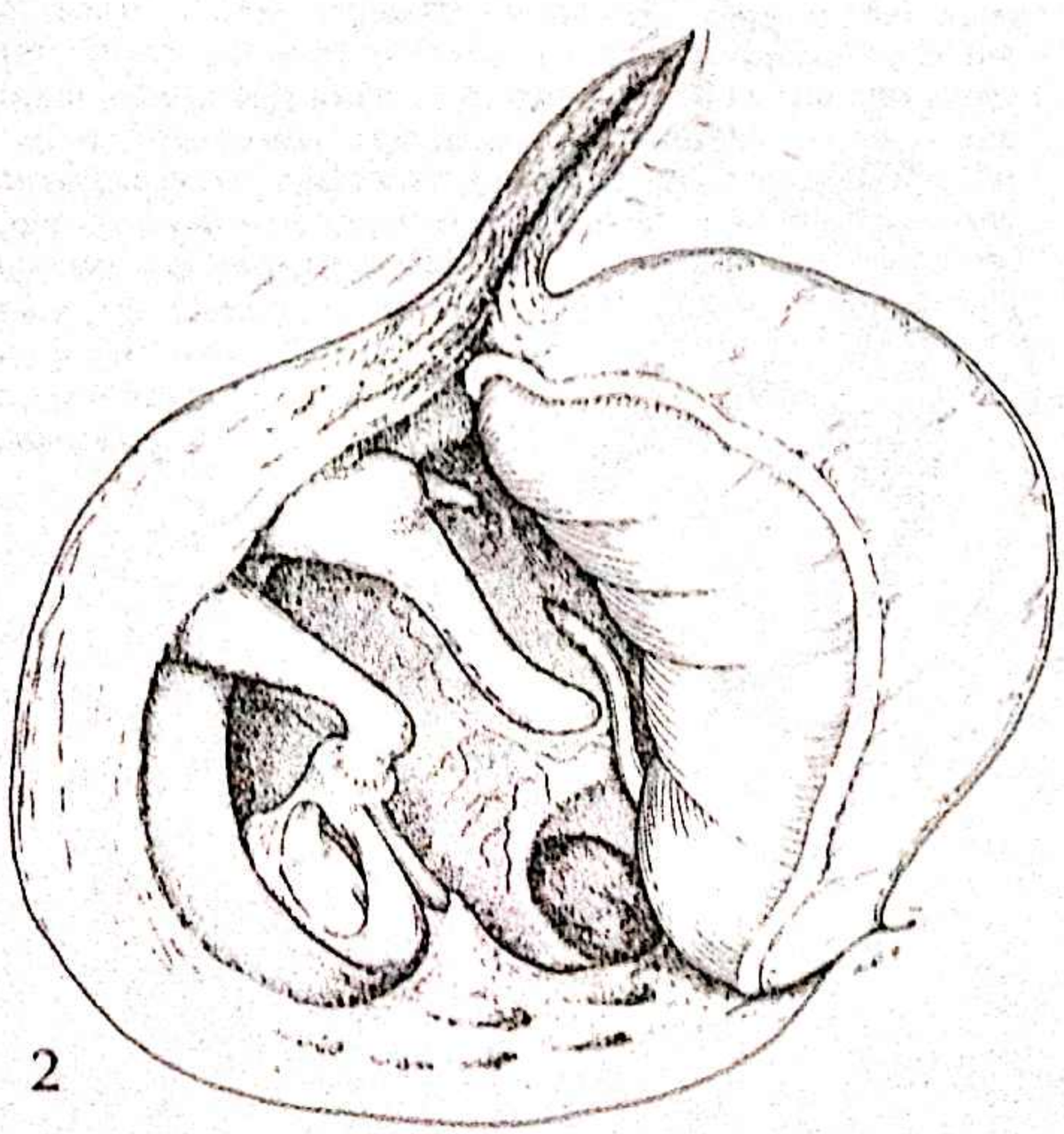


1

Exposure of middle ear

2

A tympanomeatal flap is elevated as for a stapedectomy, but the flap is separated from the handle of the malleus to allow a more extensive view of the tympanic cavity and promontory, including both labyrinthine windows, malleus, incus, stapes and pyramid with stapedius tendon, the horizontal part of the Fallopian canal and the opening of the Eustachian tube. The incus is removed with a hock, as is the stapes after dividing the stapedius tendon.

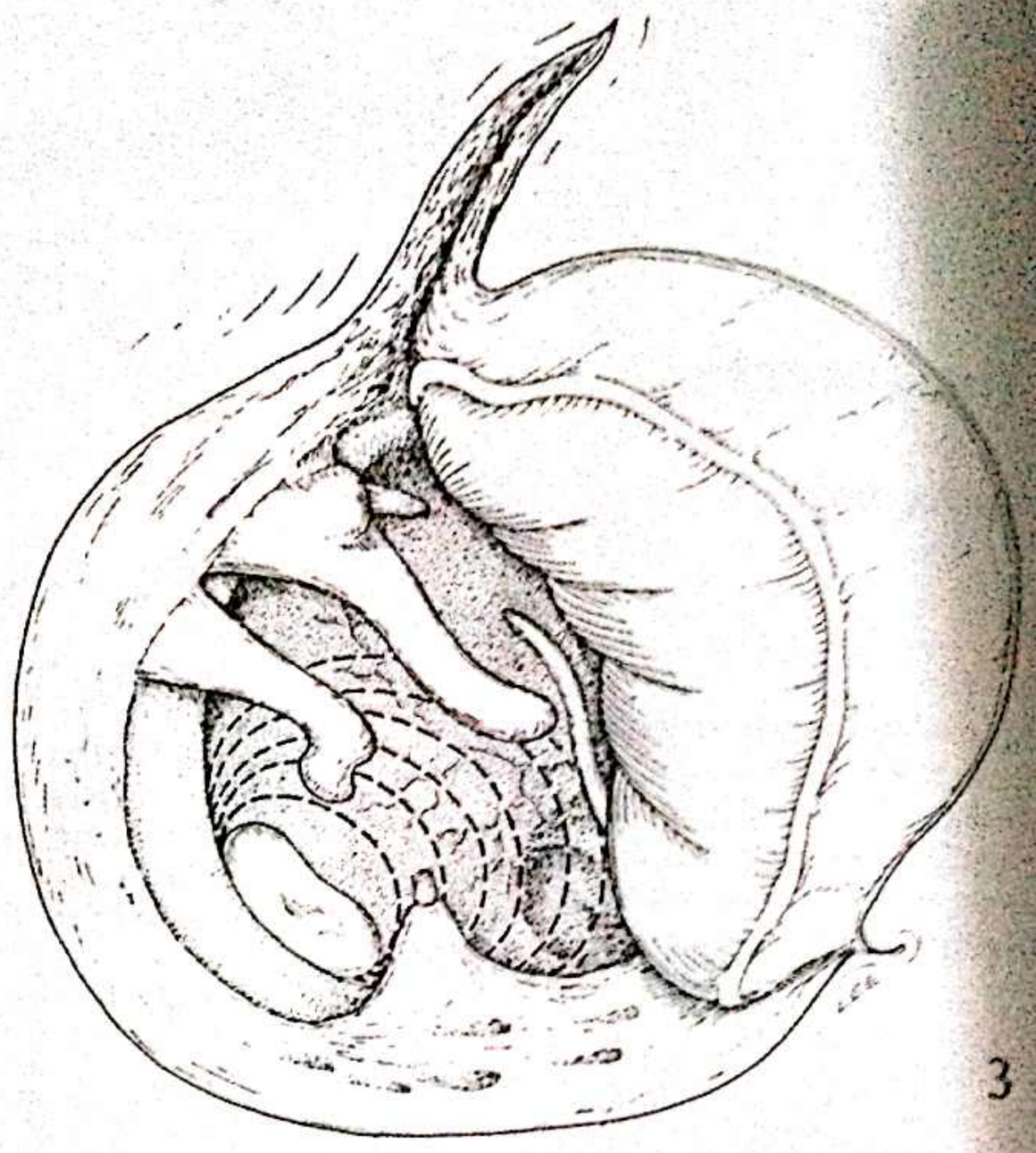


2

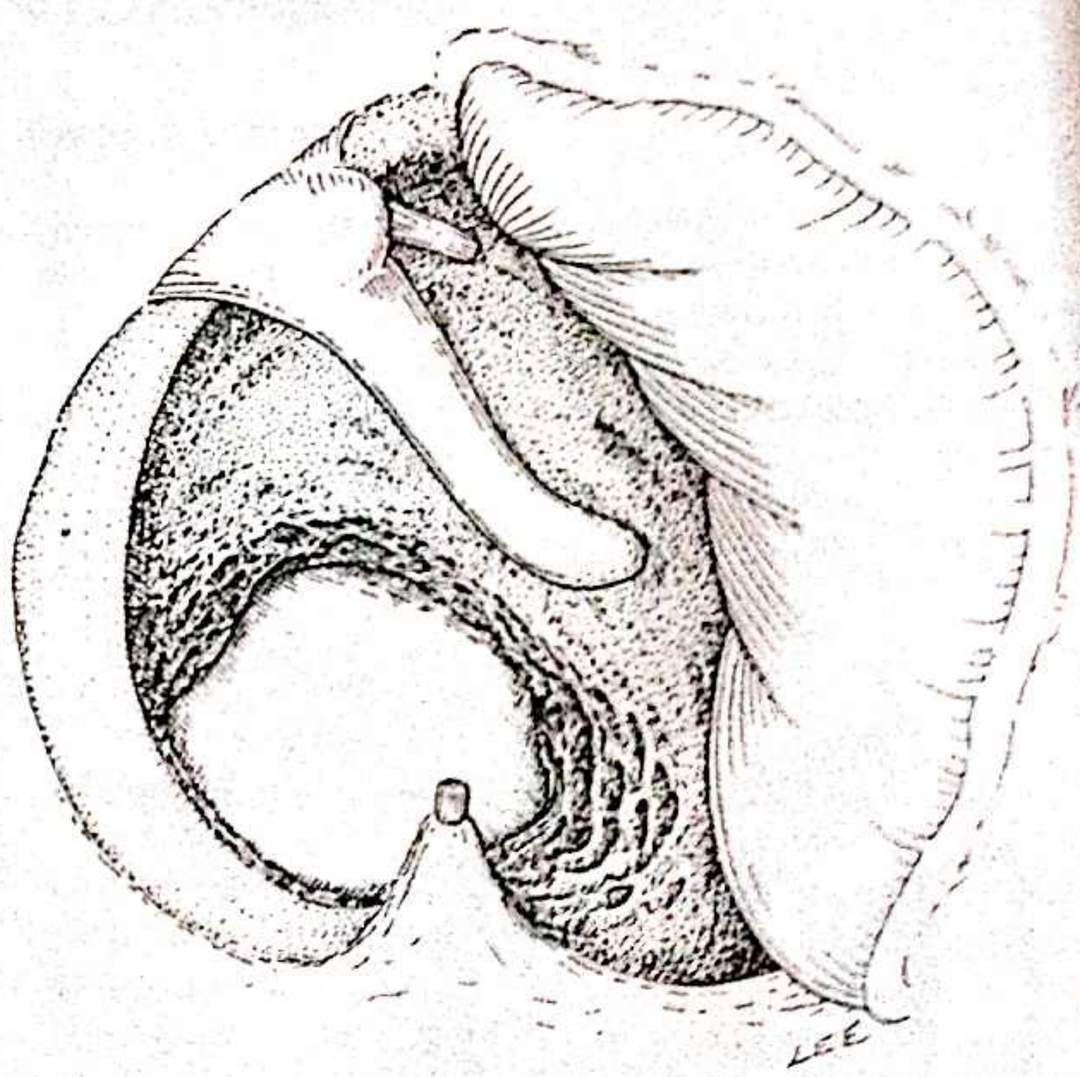
Opening the inner ear

3 & 4

The vestibule and cochlea are opened widely by drilling the promontory from the oval towards and even below the round window, as indicated by the progressive dotted lines. The medial wall of this cochleovestibular area constitutes the lateral end or fundus of the internal auditory canal. It varies in thickness. The thinnest anterosuperior area should be avoided since it contains the intrapetrous part of the facial nerve as it approaches the geniculate ganglion. The external and internal auditory canals lie in almost the same plane, and the drill should therefore be maintained in that plane. It is advisable to thin the bone as much as possible before opening the internal canal. This can be done with safety in a posteroinferior direction. If the horizontal middle ear portion of the facial nerve is dehiscent, the overhang may make it difficult to thin the bone between the circular and oval recess areas of the vestibule and internal auditory canal.



3

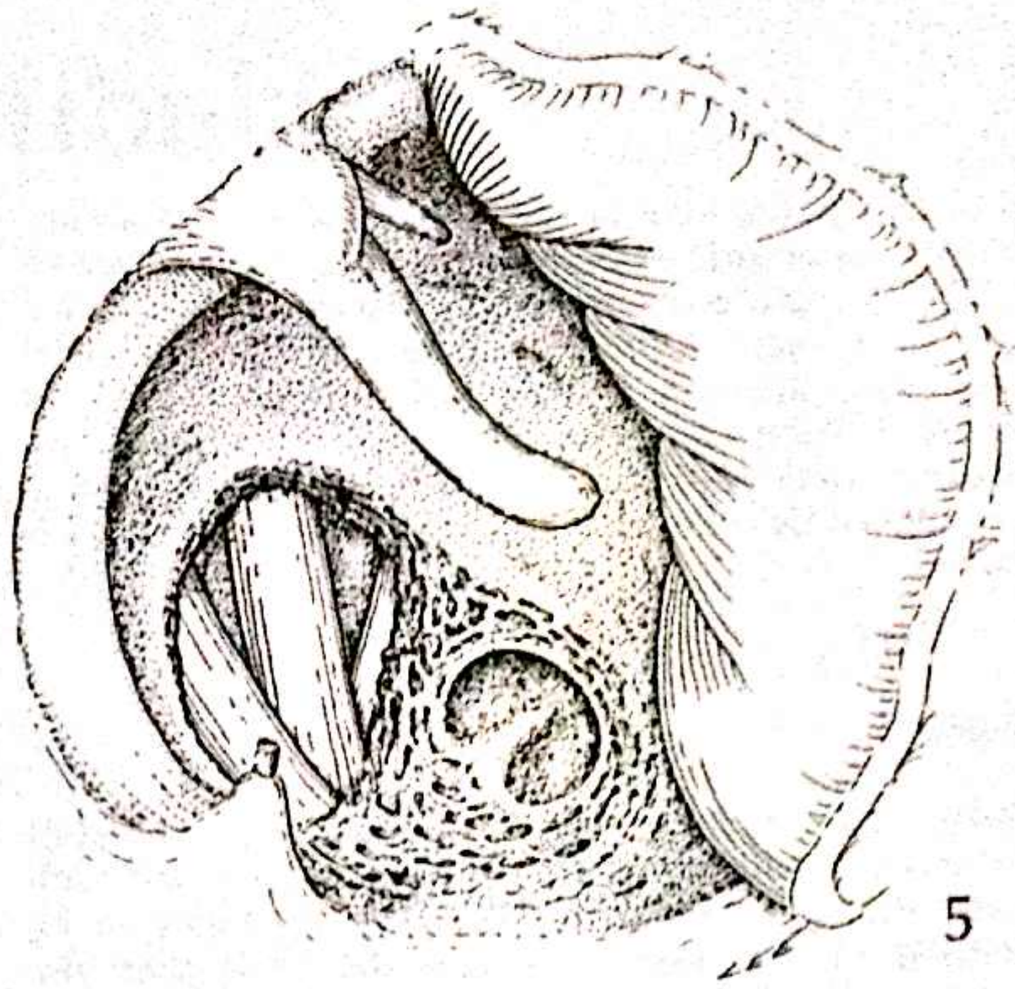


4

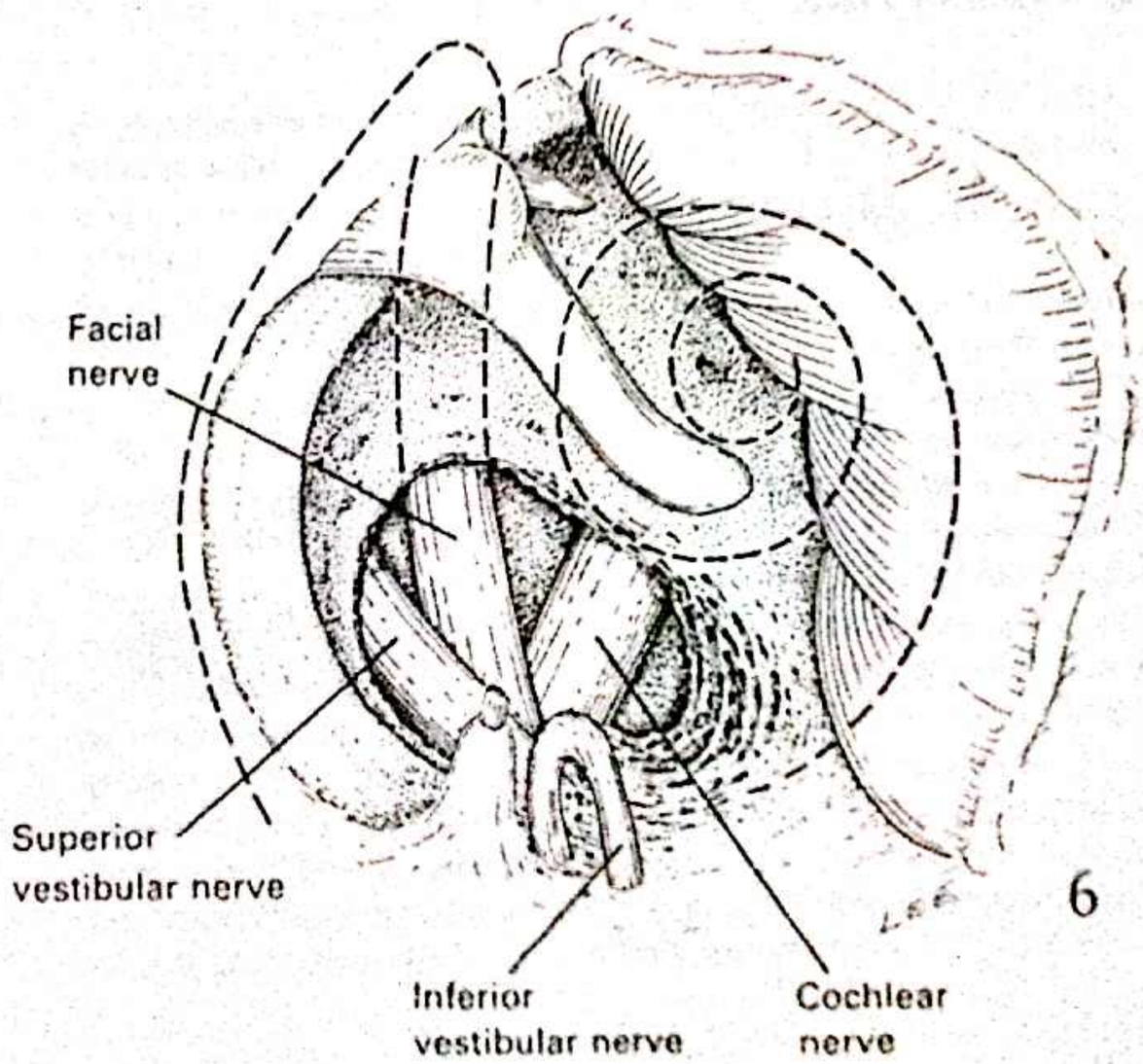
Opening the internal auditory canal

5 & 6

On completion of the drilling with diamond burrs, the dura of the internal auditory canal will be exposed as widely as possible. The dura is pierced and the flow of CSF allowed to continue with gentle suction until the trickle no longer interferes with vision and dissection. The dura can then be opened with scissors to allow identification of the neurovascular contents of the internal auditory canal. It is essential to distinguish the facial nerve situated antero-superiorly from the cochlear nerve lying inferior to it. The cochlear nerve is normally the largest neural structure in the internal auditory canal. It fans out in the modiolus anteriorly. The superior vestibular nerve is the most posteriorly placed and from this surgical approach also the most lateral. It is likely to be encountered before the other nerve structures. The inferior vestibular nerve is the smallest in diameter and is situated posteroinferiorly. The internal auditory artery and its branches should be readily visible and should be coagulated with bipolar diathermy when necessary. In perhaps 5 per cent of cases a much larger artery is visible looped in the canal. This is likely to be the anterior inferior cerebellar artery and should not be damaged.



5

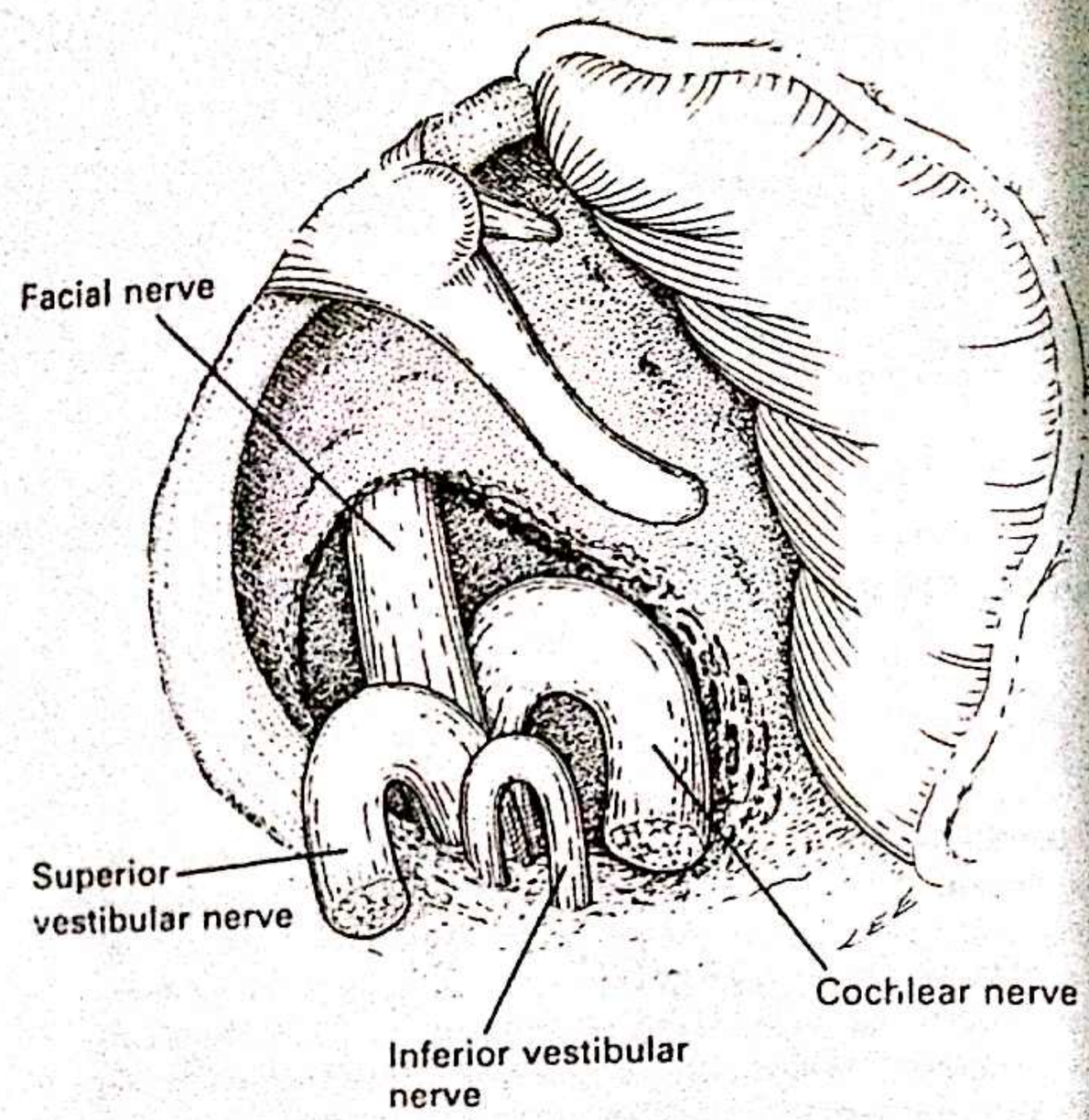


6

Neurectomy

7

The nerves in the internal auditory canal are not always distinctly separated. In particular, it may be difficult to identify the plane between the facial and superior vestibular nerves in the region of the vestibulo-facial anastomosis. Traction on the facial nerve should be avoided. A combination of blunt and sharp dissection should be used. Both vestibular nerves and the cochlear nerve should be sectioned and a small segment of each removed.



Closure

Closure is effected by gentle packing of the lateral end of the internal auditory canal with the muscle (or with adipose tissue from the abdominal wall), followed by placement of the sheet of temporalis fascia over the promontory. Fascia lata or stored dura mater are alternatives. The operation is concluded by replacing the tympanomeatal flap and suturing the preauricular incision. An external ear canal pack and dressing are kept in place for 5 to 7 days.

Complications

Patients should be warned about possible complications before they agree to surgery.

CSF leak is by far the commonest complication. Minor leaks may seal with sedation and rest in the sitting-up position. If necessary a spinal drain may be inserted and left in place for 4 to 5 days. Re-exploration and repacking of the operation site is rarely required.

Meningitis is an uncommon complication which should be avoided by the use of prophylactic antibiotics. When indicated, CSF should be taken by lumbar puncture and examined. Chloramphenicol therapy may be necessary.

Postoperative otitis media is possible but infrequent. It should respond to appropriate therapy.

Temporary facial paralysis, partial or complete, of sudden or delayed onset is a possibility. Permanent facial paralysis is unlikely. After any facial nerve lesion the extent of recovery is very variable. Prophylactic steroids should be used. Even in experienced hands the risk to the facial nerve is of the order of 2 to 3 per cent.

Illustrations by Sally Mays

Retrolabyrinthine vestibular neurectomy

Herbert Silverstein MD
President, Ear Research Foundation;
Clinical Professor of Surgery, Division of Otolaryngology, University of South Florida, USA

Horace Norrell MD
Active Staff, Sarasota Memorial Hospital, Sarasota, Florida, USA

Alan B. McDaniel MD
Associate Professor of Otolaryngology, University of Louisville, Kentucky, USA

Thomas Haberkamp MD
Clinical Fellow, Ear Research Foundation, Sarasota, Florida, USA

The retrolabyrinthine approach offers excellent exposure of the cerebellopontine angle with little morbidity. The commonest procedure performed via this approach is the retrolabyrinthine vestibular neurectomy (RVN). Retrolabyrinthine total vestibular neurectomy is a safe and effective treatment for the vertigo of Menière's disease and other inner ear derangements. It combines exellent control of vertigo with preservation of hearing and is associated with few complications.

Preoperative

Investigations

Preoperative evaluation consists of a thorough otoneurological examination. Special testing routinely includes pure tone audiometry with acoustic reflex testing, brainstem evoked response audiometry (BAER), electronystagmography (ENG), electrocochleography (ECoG), radiographic examination of the internal auditory canals, and CT scanning of the posterior fossa.

Signs of bilateral disease, central balance disorders and anacousis in the opposite ear are contraindications to vestibular neurectomy.

Preoperative preparation and anaesthesia

The operation is performed under general endotracheal anaesthesia, with the patient supine and positioned for mastoidectomy. Neuromuscular paralytic intraoperative agents should not be used, as facial function may be tested during the procedure. The scalp is shaved to 3 cm above and 7 cm behind the ear, and the field is prepared with povidone-iodine (Betadine). The procedure begins by removing adipose tissue from the lower left quadrant of the abdomen for later obliteration of the mastoid cavity.

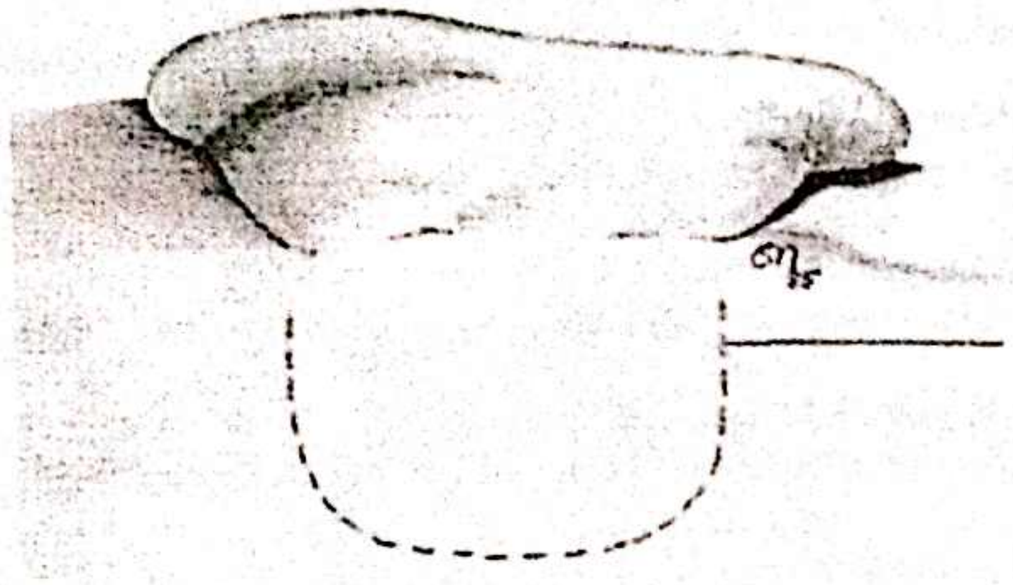
The operation

A prophylactic antibiotic, e.g. nafcillin, is administered before, during and immediately after the operation. A urinary catheter is inserted. The area of the incision is infiltrated with 6–10 ml of 1 per cent lignocaine (lidocaine) with adrenaline (epinephrine) 1:100 000.

The incision

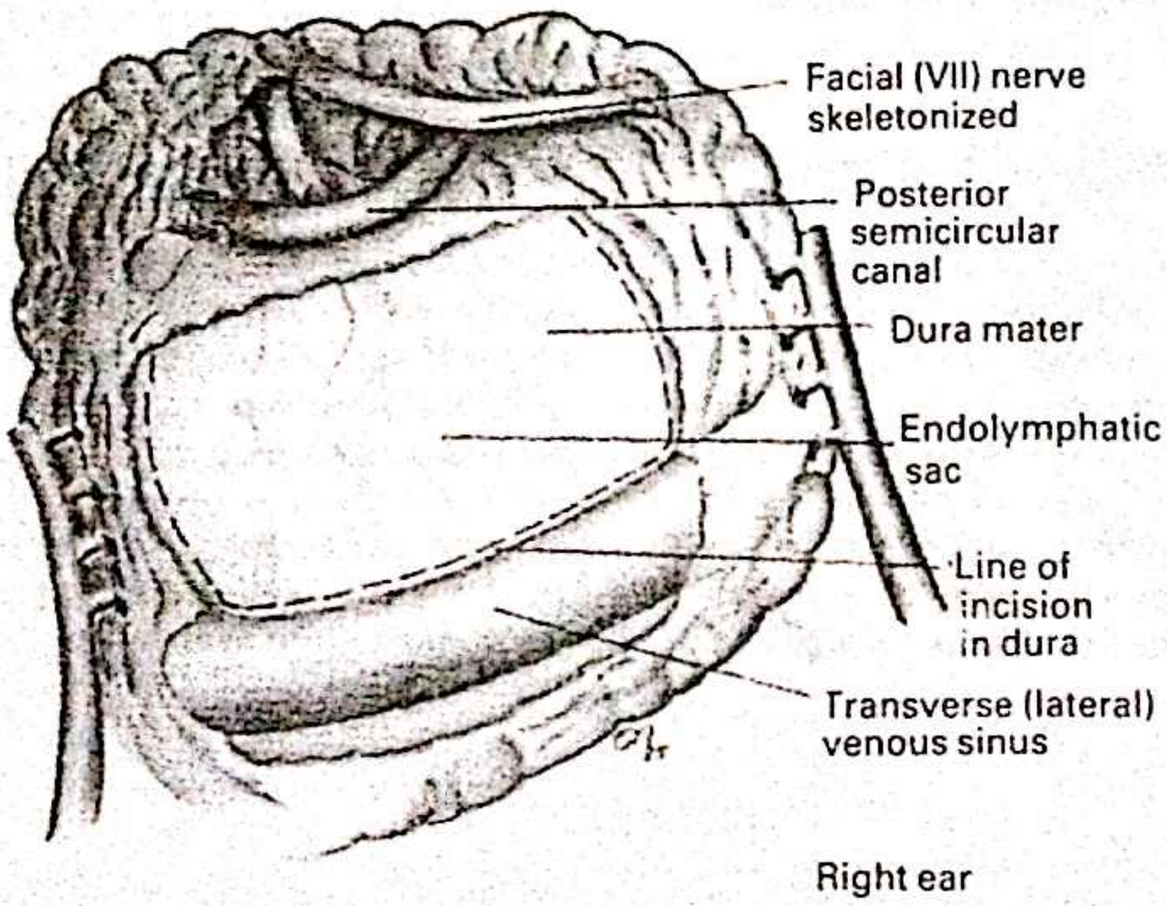
1

A postauricular U-shaped incision is made through the skin and muscle to create an anteriorly based flap extending from the mastoid tip to the top of the helix, 4 cm behind the postauricular crease. The periosteum is cut from the bone and elevated with the flap. Bleeding from the emmissary vein is controlled with electrocautery and bone wax. A large temporalis fascia graft, 2 × 4 cm, is obtained and set aside to dry.



Right ear

1



Extended mastoidectomy

2

Intravenous mannitol 1.5 g/kg is begun when drilling is started. An extended mastoidectomy with exposure of the endolymphatic sac is then performed, skeletonizing the lateral venous sinus and 4 mm of the posterior fossa dura. Any bleeding from the lateral sinus is controlled with compressed microfibrillar collagen, backed with compressed absorbable gelatin sponge or Surgicel.

Right ear

2

3

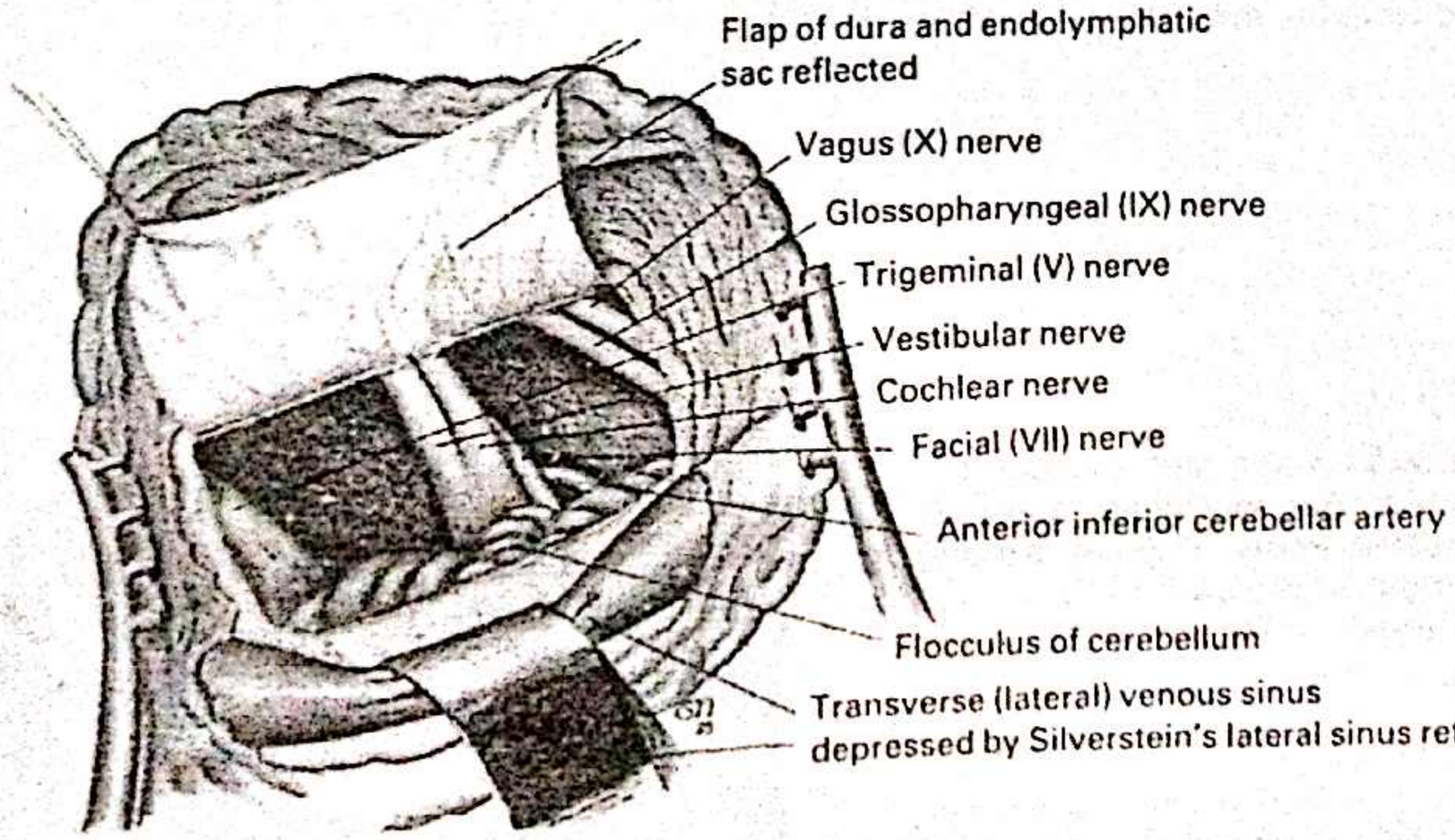
The lateral sinus is flattened with a Silverstein lateral sinus retractor and the remaining bone is removed with rongeurs. The following structures should be identified before the dura is opened: the mastoid segment of the facial nerve, the jugular bulb, the superior petrosal sinus, the horizontal and posterior bony semicircular canals, and the endolymphatic duct as it enters the labyrinth.

The posterior fossa dura is incised around the endolymphatic sac using a 59 m Beaver knife and Jacobsen scissors. A 2 mm dural cuff is allowed to remain on the lateral and petrosal sinuses for later closure of the dural defect. The anteriorly based flap of endolymphatic sac and dura is reflected on to the labyrinth. The cerebellum may herniate slightly through the dural defect until cerebrospinal fluid (CSF) is released from the lateral cistern. A rubber glove or Silastic sheeting cut to 1 × 3 cm is placed against the cerebellum for protection. The cerebellum is gently compressed to allow visualization of the arachnoid layer. Using the blunt arachnoid dissector, an opening is made in the arachnoid layer to release CSF from the cerebellopontine angle cistern. At this point the cerebellum falls away, allowing excellent exposure of the contents of the cerebellopontine angle.

From superior to inferior the following structures should be routinely identified in the cerebellopontine angle: the tentorium cerebelli, the trigeminal nerve and root entry zone, the petrosal veins, the flocculus of the cerebellum partially overlying the VIIIth cranial nerve, the facial nerve, the anterior inferior cerebellar artery, and the IXth, Xth and XIth cranial nerves. The VIIIth nerve can normally be found 2 cm deep to the point at which the posterior semicircular canal bisects the vertical facial nerve. In the posterior fossa, the facial nerve is hidden by the VIIIth cranial nerve, which must be retracted slightly to allow identification of the facial nerve.

The facial nerve nearly always enters the brainstem 2–3 mm caudal and anterior to the entry of the VIIIth cranial nerve. It is usually separated from the VIIIth nerve by a loop or branch of the anterior inferior cerebellar artery. From the porus to the brainstem the facial nerve is quite variable in its relationship to the VIIIth nerve. It may be directly anterior to it, adjacent to the vestibular portion, or adjacent to the cochlear divisions. It is rarely adherent to the VIIIth nerve (4%).

The anterior aspect of the VIIth and VIIIth cranial nerves should always be examined with a small mirror to determine the anatomy that is hidden from the surgeon's direct view. The vascular anatomy is most variable in relation to the VIIth and VIIIth cranial nerves. All vessels are preserved, if possible, being moved when necessary to perform the vestibular neurectomy. The flocculus usually hides 5 mm of the VIIIth nerve and may have to be dissected away from it to allow better visualization.



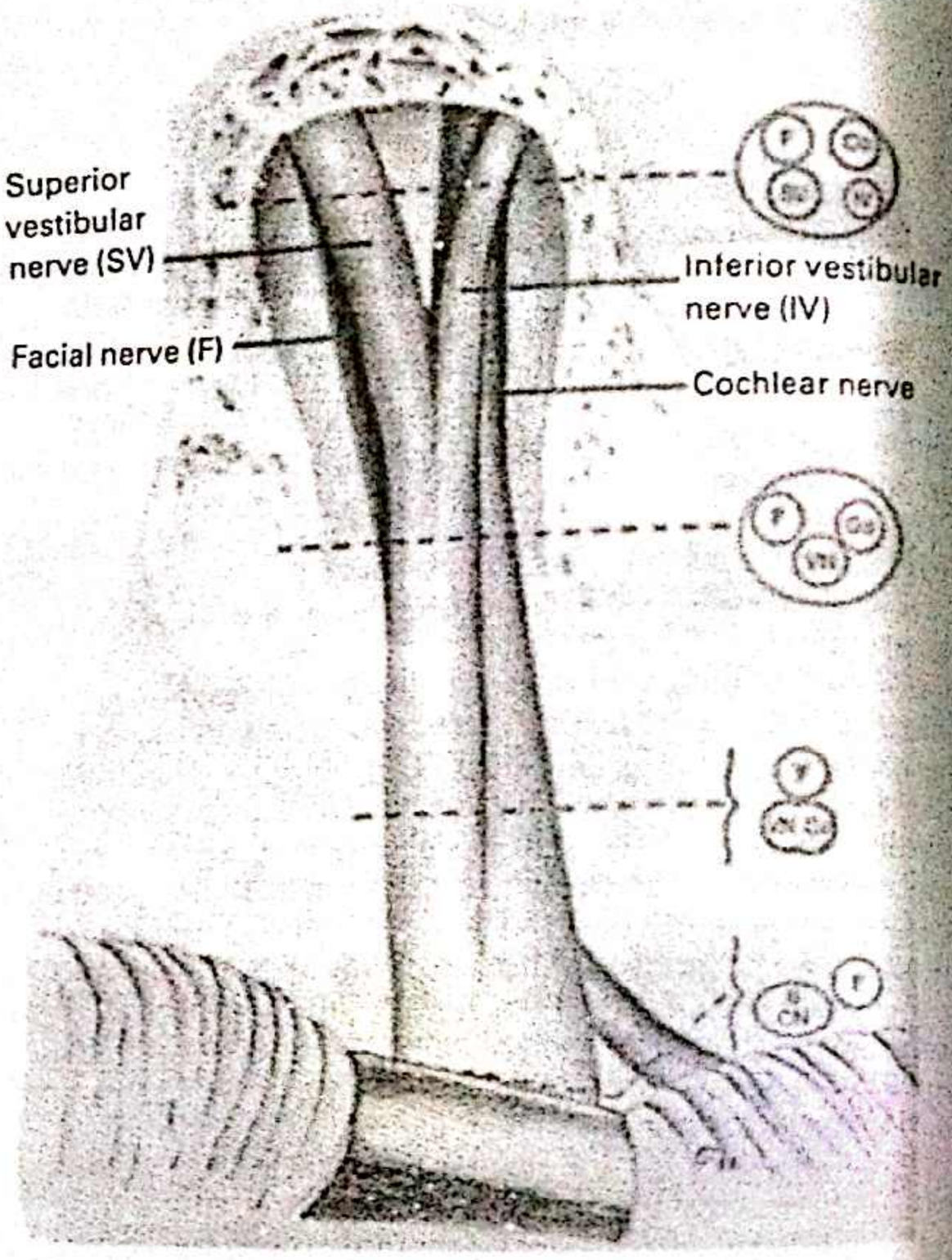
3

4

It is important to understand that the plane of the cochlear and vestibular nerves (the C–V plane) rotates by 90° from the labyrinth to the brainstem. In the posterior fossa, seen from the retrolabyrinthine approach, with the patient in the supine position, the cleavage plane faces the surgeon along an anterior-posterior axis, while near the distal end of the internal auditory canal the cleavage cannot be seen since the nerves have rotated 90° to a superior-inferior axis. At this point, if the internal auditory canal is opened, the cochlear nerve is completely hidden by the vestibular nerve. This concept of the 90° rotation of the cleavage between cochlear and vestibular nerves is not appreciated in the neurosurgical literature.

The next step is to separate the cochlear and vestibular nerves by sharp dissection in the cochleovestibular cleavage plane. The cleavage can be identified in 75% of cases by a fine septum at the mid-portion of the nerve. Other helpful landmarks are a vessel running along the C–V plane, a colour differential (the cochlear nerve appears whiter and the vestibular nerve greyer), and the nervus intermedius, which may be seen on the medial aspect of the VIIIth nerve with a mirror, indicating the C–V plane. If the C–V plane cannot be identified the VIIIth nerve is divided in the mid-portion and the superior half transected. The cochlear and vestibular fibres in the posterior fossa are arranged so that the vestibular fibres are always superior, near the Vth cranial nerve, and the cochlear fibres inferior, near the IXth cranial nerve. In the suboccipital approach with the patient's head flexed, the surgeon sees the cochlear division, since the exposure is more inferior.

The perineurium is then incised with a sharp sickle knife and the nerves are separated with a fine spatula and/or a fine nerve hook introduced from the medial aspect of the nerve.



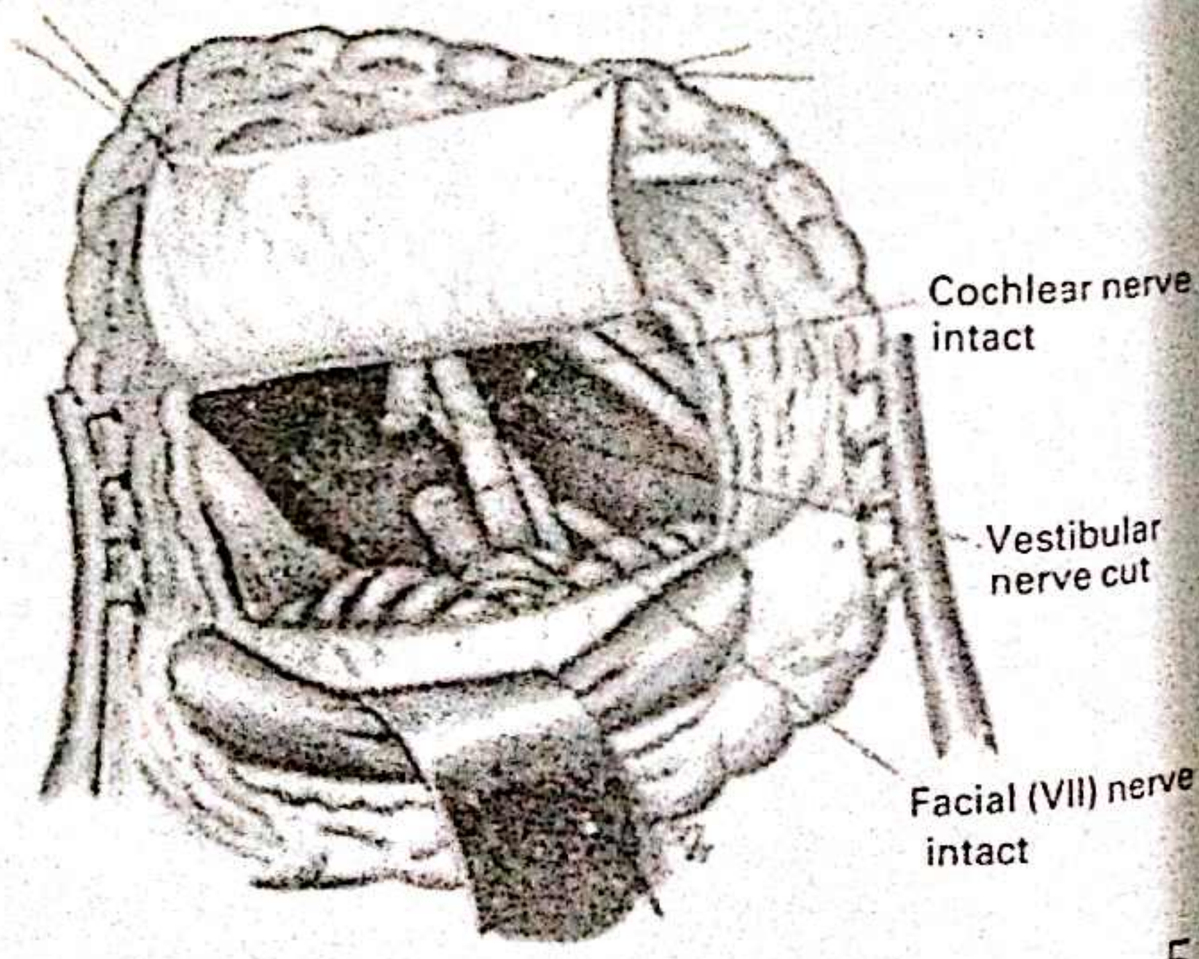
4

Vestibular neurectomy

5

Once the position of the facial nerve and surrounding vessels has been reaffirmed, the vestibular nerve is transected with suitable microscissors. If there are any important structures near the medial aspect of the nerve, only three-quarters of the nerve are transected with the scissors and the remaining vestibular fibres are cut with the sickle knife.

The wound is irrigated with bacitracin 25 000 i.u./l and the dura is closed with three or four 0 silk sutures. The large piece of temporalis fascia is placed over the dural closure and over the aditus and facial recess. All bone dust should be irrigated from the middle ear to prevent fixation of the stapes. The mastoid cavity is filled with pieces of abdominal adipose tissue obtained from the left lower quadrant. The wound is closed without a drain and a mastoid dressing is applied.



5

Postoperative care

Because mannitol may produce potassium depletion during surgery, KCl 20 mmol/l is added routinely to the postoperative intravenous fluid. Serum electrolytes are measured shortly after the operation. In patients with Menière's disease another cause of potassium depletion is the common use of diuretics before surgery.

Patients have vertigo for 12 to 36 hours postoperatively, the severity depending on residual vestibular function before surgery. Brisk first, second and third degree nystagmus is seen for 24 hours. Vestibular sedatives and anti-emetics are given as necessary.

The mastoid dressing is replaced after 48 hours and removed after 72 hours. The abdominal drain and Foley catheter are removed on the first day. After 24 hours patients are usually able to tolerate liquids, and the intravenous fluid (5% glucose in 0.2 mol/l saline) is discontinued. Should vomiting persist, the intravenous fluid is continued at 150 ml/24 hours. The patient is allowed to walk on the second postoperative day and may be discharged on the fourth or fifth day.

References

1. De La Cruz, A., McElveen, J. T. Hearing preservation in vestibular neurectomy. Laryngoscope 1984; 94: 874–877

2. Hitselberger, W. E., Pulec, J. L. Trigeminal nerve (posterior root) retrolabyrinthine selective section. Archives of Otolaryngology 1972; 96: 412–415

3. Martin, R. G., Grant, J. L., Peace, D., Theiss, C., Rhoton, A. L. Jr. Microsurgical relationships of the anterior inferior cerebellar artery and the facial-vestibulocochlear nerve complex. Neurosurgery 1980; 6: 583–607

4. McDaniel, A. B., Silverstein, H., Norrell, H. Retrolabyrinthine vestibular neurectomy with and without monitoring of eighth nerve potentials. American Journal of Otology, Supplement Issue 1985, Nov: 23–26

5. McKenzie, K. G. Intracranial division of the vestibular portion of the auditory nerve for intractable vertigo, with report of two cases. Transactions of the Academy of Medicine (Toronto) 1932

6. Silverstein, H., Norrell, H. The retrolabyrinthine approach to the cerebellopontine angle. In: Neurosurgical Surgery of the Ear, Vol. 2, pp. 318–322. Birmingham, Alabama: Aesculapius Publishing, 1979

7. Silverstein, H., Norrell, H. Retrolabyrinthine vestibular neurectomy. Otolaryngology. Head and Neck Surgery 1982; 90: 778–782

8. Silverstein, H., Wazen, J., Norrell, H., Hyman, S. M. Retrolabyrinthine vestibular neurectomy with simultaneous monitoring of eighth nerve action potentials and electrocochleography. American Journal of Otology 1984; 5: 552–555

Illustrations by Halcyon Harris Winter

Acoustic neurilemmoma surgery via the retrosigmoid approach

Mansfield F. W. Smith MD, FACS
Ear Medical Clinic, San Jose, California;
Clinical Associate Professor of Surgery, Stanford University Medical Center, Stanford, California, USA

Raymond L. Lagger MD
Assistant Clinical Professor of Neurosurgery, University of California, San Francisco, California, USA

Indications

Preservation of hearing in patients with acoustic neurilemmomas is a logical extension of micro-neuro-otological surgery. The concept of total tumour removal and maximum sparing of adjacent normal neural tissue is consistent with efforts to retain cochlear function. Preservation of hearing is a realistic goal in patients with functionally normal hearing (speech discrimination score of 80 per cent or better) and a tumour extending 15 mm or less from the porus acusticus into the cerebellopontine angle. Every effort should be made to conserve hearing if the tumour involves the only hearing ear. Sound localization and signal selection (ability to discriminate speech in background noise) are important features of binaural hearing and when lost represent a disability.

Two approaches have been described for the removal of acoustic neurilemmomas with preservation of hearing: the retrosigmoid (modified suboccipital) approach[1–7] and the middle fossa approach[8–10]. The retrosigmoid approach is preferred because of superior exposure and less morbidity.

Small unilateral acoustic neurilemmomas in patients with ipsilateral non-functional hearing are best removed by the translabrynthine approach. Larger tumours may be removed via the translabrynthine or suboccipital (retrosigmoid) approach, or by a combination of these, depending on the experience and preference of the operator.

It is rarely necessary to convert a retrosigmoid to a translabrynthine approach when dealing with small or medium-sized acoustic neurilemmomas. Such conversion destroys the inner ear.

Diagnosis

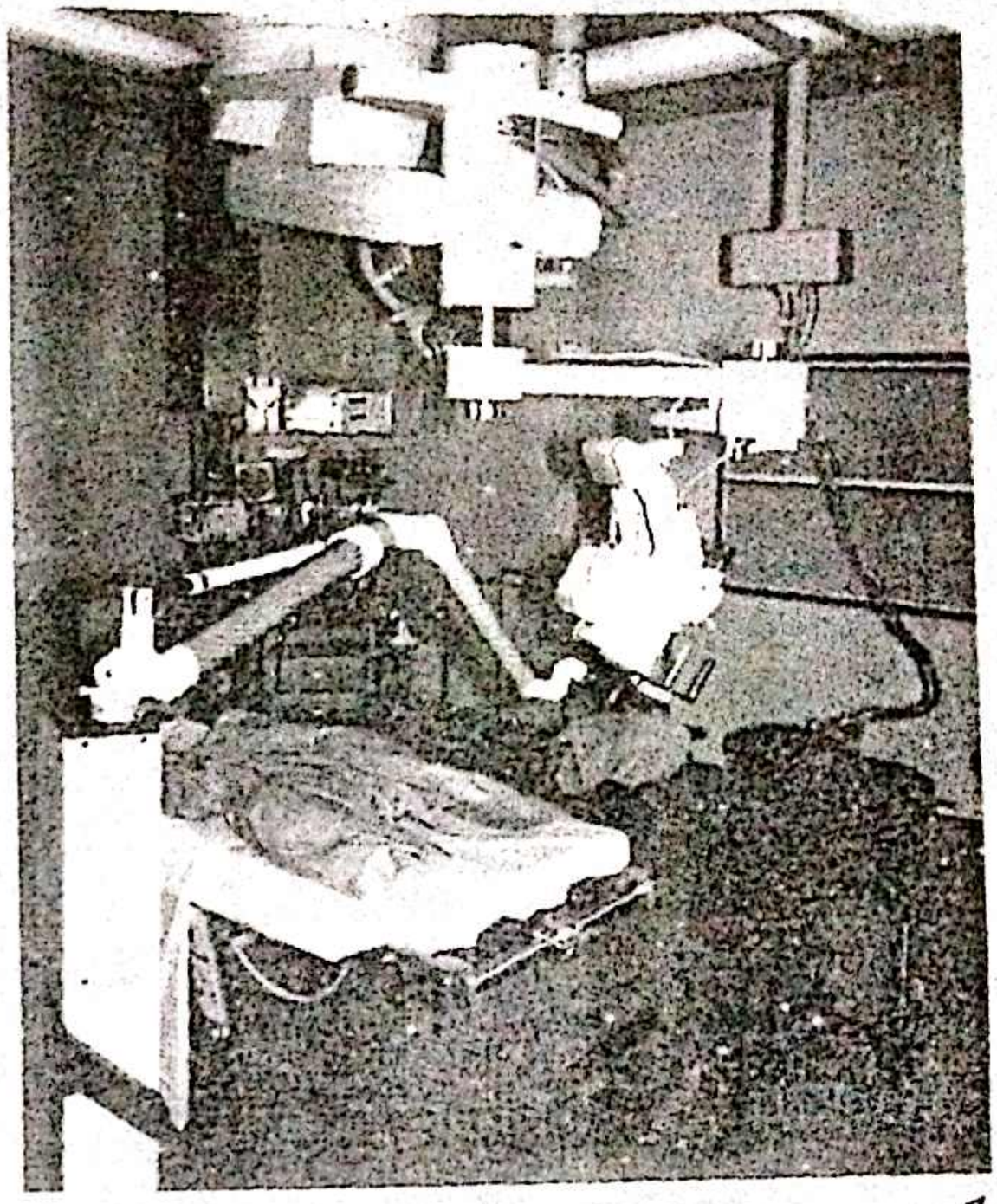
Early diagnosis of internal auditory canal and cerebellopontine angle lesions offers the best prospect of hearing conservation. A high index of suspicion is therefore necessary when evaluating minor auditory symptoms. Minor differences in hearing between the ears, unexplained tinnitus, or pressure in one ear all require appropriate neuro-otological evaluation. If audiometry (including pure tone testing, speech reception threshold and speech discrimination testing) reveals any unexplained differences further investigation is indicated. This includes testing of brainstem electrical responses (BER, evoked potentials) and electro-nystagmography (ENG). If either the BER or ENG are abnormal, more sophisticated investigations such as high-resolution computerized axial tomography (CAT) and air-contrast CAT scanning may be needed.

Equipment

1 & 2

The operating room should be equipped with a ceiling-mounted microscope (e.g. Moller–Wedel) and a surgeon's chair which includes the controls for the microscope, video system and photographic equipment. An electrically controlled operating table (e.g. Magnet) capable of 35° side rotation is ideal, as this allows the majority of patients with acoustic neurilemmoma to be operated on in the horizontal supine position. A mouldable contour mattress (e.g. Vac-Pac) taped to the operating table is useful for positioning and protecting the patient, as well as for securing him to the table. A carbon dioxide laser is connected to the microscope. This arrangement minimizes clutter in the operating theatre. We use the Coherent 450 carbon dioxide laser system in which the laser head can be separated from the console, which further reduces clutter. Since the energy of this laser is strongly absorbed by water, any tissues covered by spinal fluid or irrigating fluid, or materials soaked with these fluids, are protected from the beam.

The laser head is positioned at the head of the table. The nurse is directly opposite the surgeon, and the anaesthetist at the foot of the table on the same side as the nurse. A video camera (Urban) is part of the microscope system and two 19-inch video screens are within easy view of the nurse and anaesthetist. This arrangement has the advantage that nursing staff can follow details of the dissection and learn to anticipate the requirements of the surgeon; that the entire team takes more interest in the surgical procedure; and that the video is invaluable as a teaching aid.

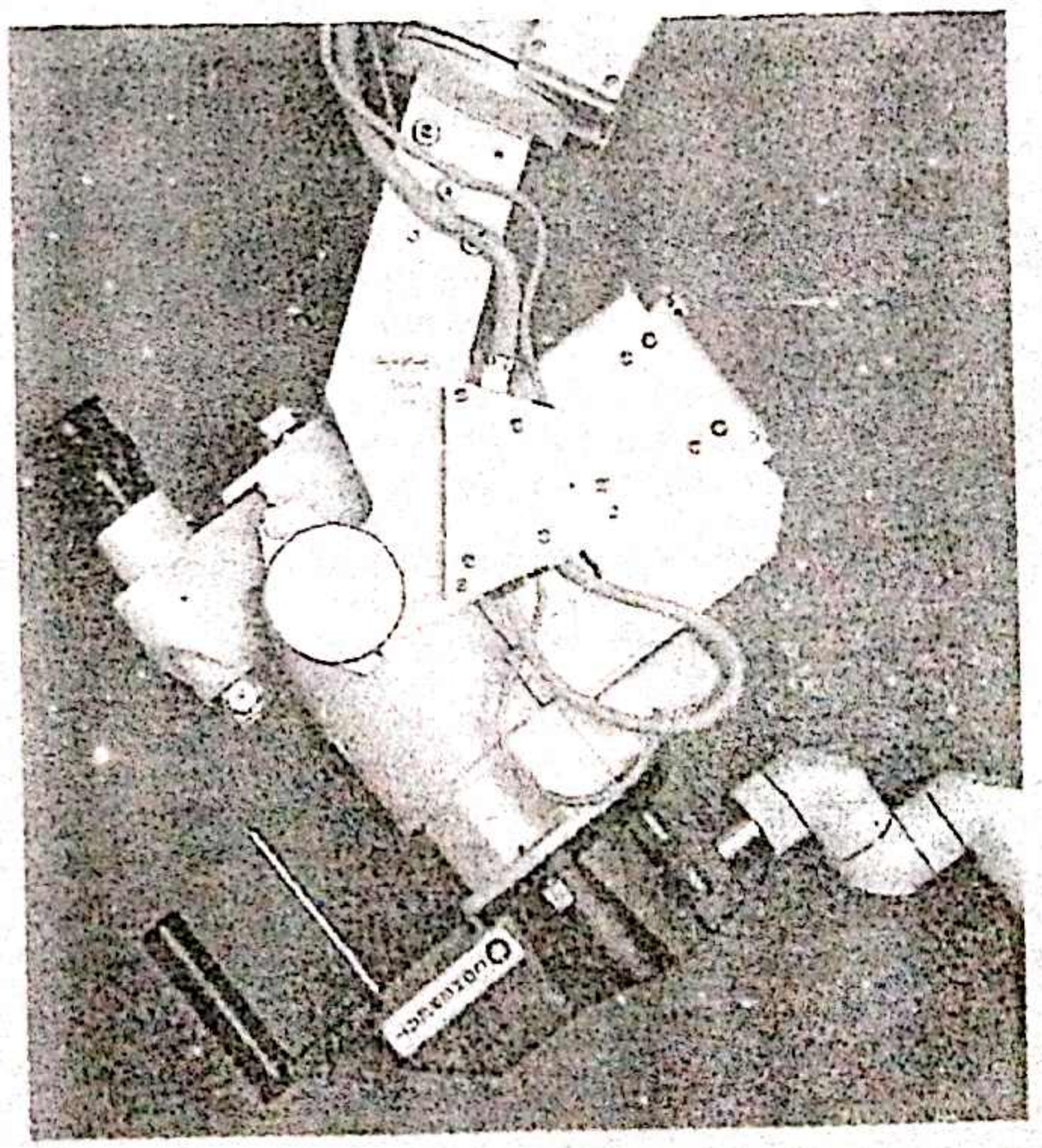


1

Position of patient

The patient is placed in the supine position. Older patients and those with limited range of movement of the cervical spine may be placed in the prone position with the head turned to the side and immobilized laterally on a three-pronged headrest.

The patient must be safely secured to the operating table to avoid slipping during extreme lateral rotation. A Steri-Drape irrigation pouch (3M) just posterior to the retrosigmoid incision is useful for collecting irrigation fluids, blood, CSF and bone dust. This pouch is drained by operating room suction.



2

Anaesthesia

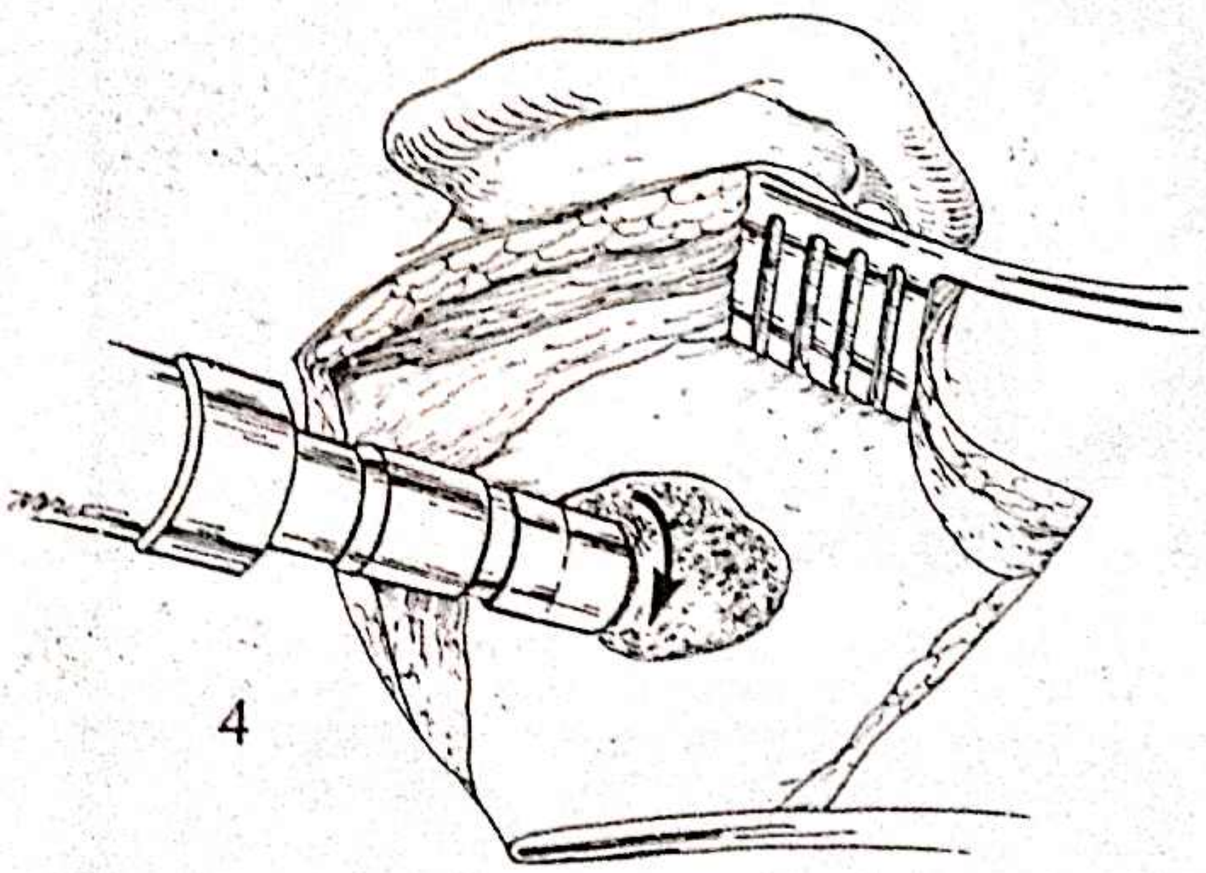
Most patients are pretreated with dexamethasone 4 mg, intravenous mannitol 1.5 g/kg and nafcillin sodium (Nafcillin) 2 g intravenously at the time of induction. If mannitol is used, the patient must be catheterized.

The operation

The incision

3

A retroauricular hockey stick incision is made, with the inferior limb approximately 1–2 cm below the mastoid tip.

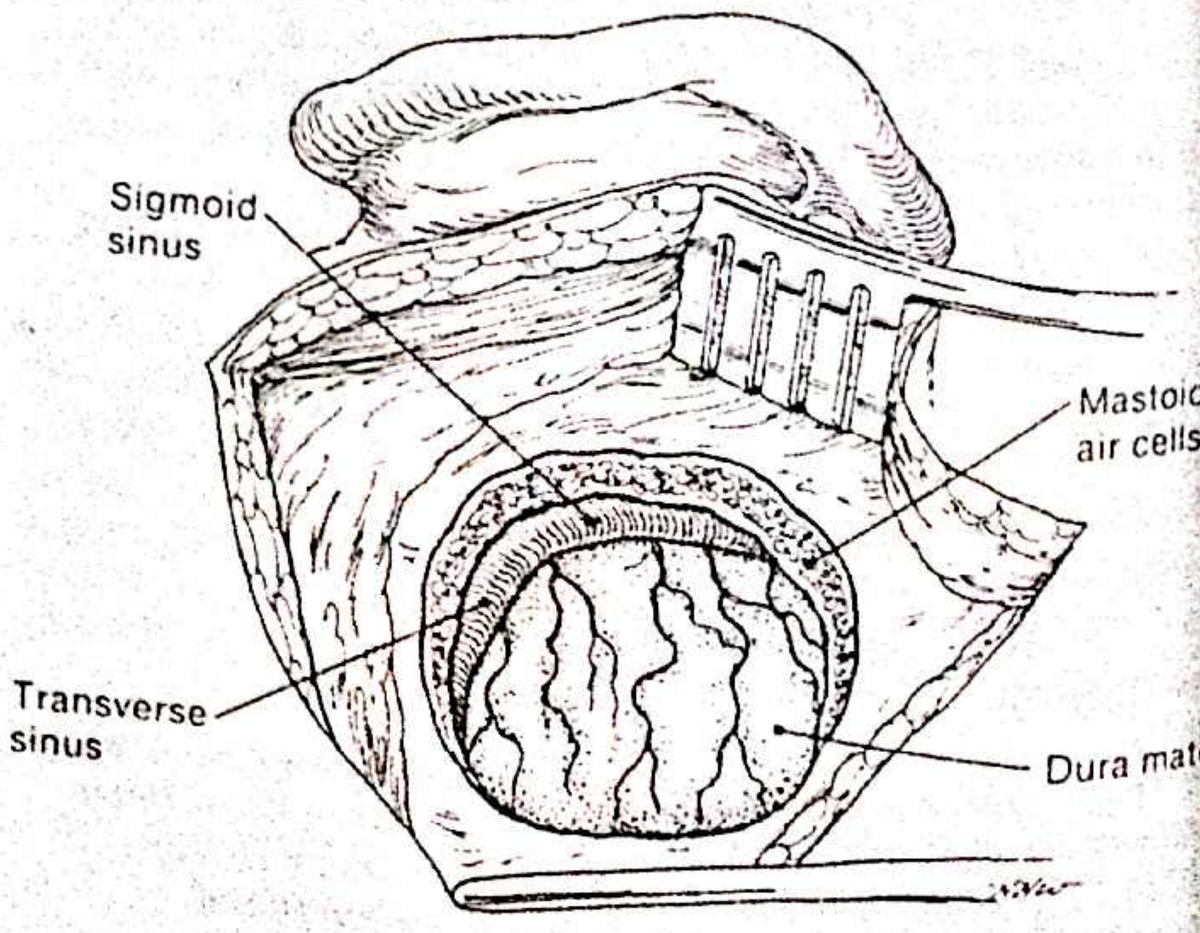


4

A retrosigmoid craniotomy is carried out with generous bony exposure (approximately 5 cm).

5

Wide lateral exposure is required for visualization in the angle and internal auditory canal, and sufficient bone is removed to expose both the sigmoid and the transverse sinus. If the patient has a very large, well-developed mastoid cavity, a complete mastoidectomy may be performed, which is expanded to remove the bone over the posterior fossa dura, sinodural angle, mastoid tip and jugular bulb. The sigmoid sinus, including the dural reflexion, can then be retracted anteriorly into the mastoid cavity, providing better exposure of the angle, particularly the area of the porus acusticus.



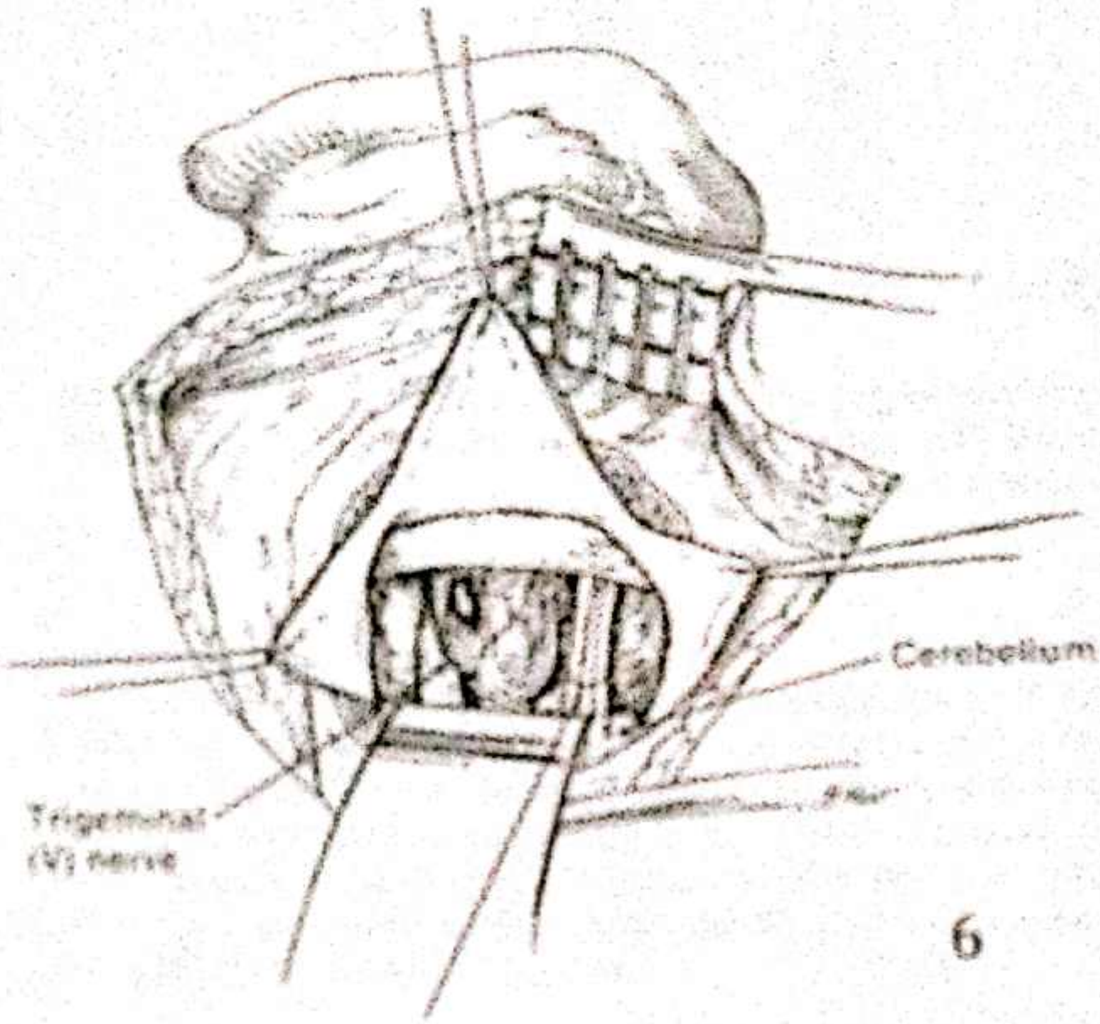
5

6

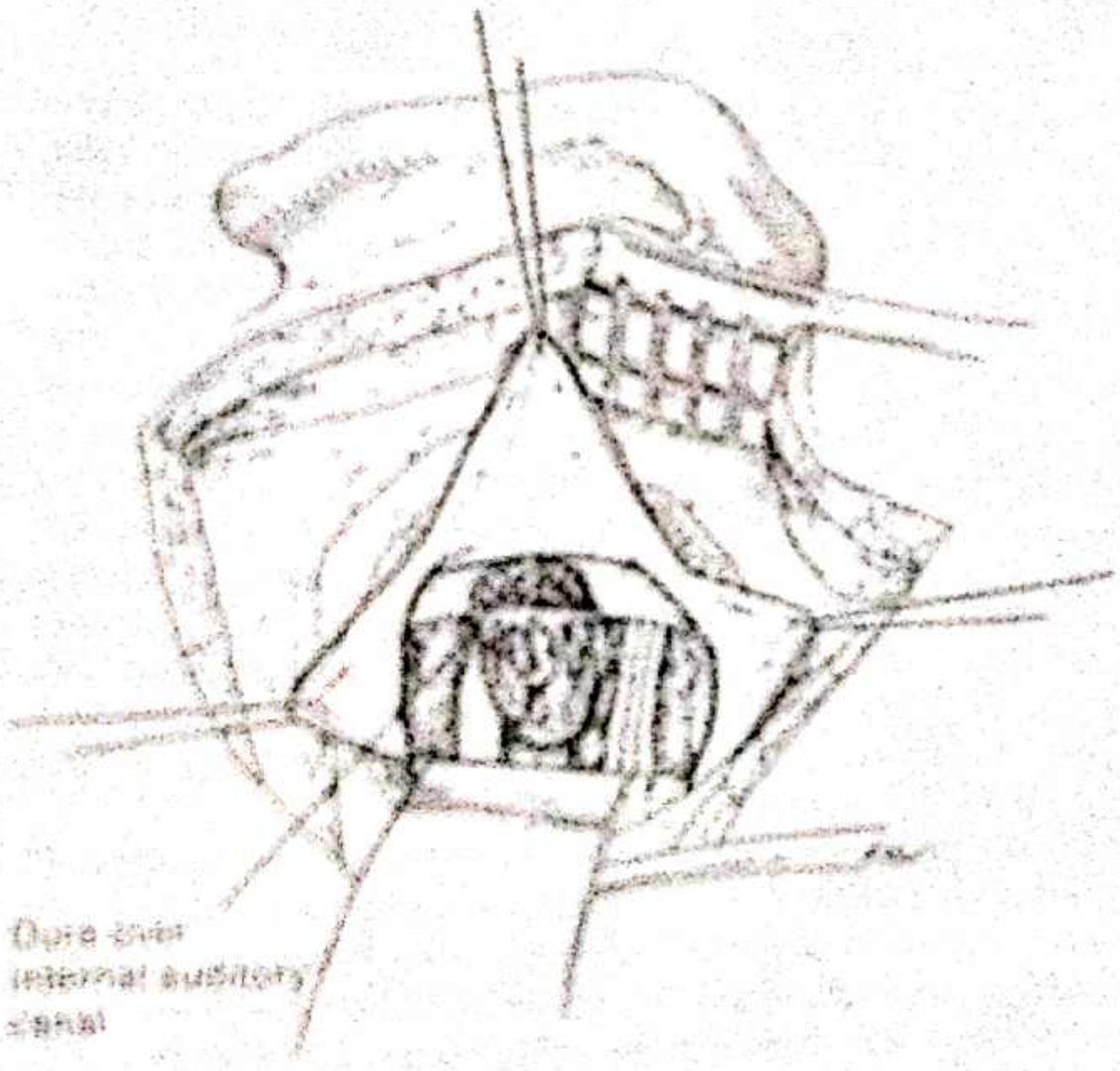
The dura is opened in a cruciate fashion and retracted with stay sutures.

Cerebellar distension may be minimized by tilting the patient 'head up' and by the use of steroids, mannitol, hyperventilation and CSF drainage.

Collagen sponge, e.g. Bucol (Coolman), is placed against the cerebellum to protect it from damage. A self-retaining Leyla type retractor secured to the operating table is used for limited gentle retraction of the cerebellum. Opening the arachnoid of the cisterna magna allows prompt egress of cerebrospinal fluid and provides excellent cerebellar relaxation and exposure of the tumour with a minimum of retraction. To avoid injury to surrounding cranial nerves and brainstem blood supply, the arachnoid over the tumour must be opened, using sharp dissection. The tumour can then be exposed in the subarachnoid plane.



6



7

Once the posterior aspect of the tumour has been exposed, the dura (periosteum) lateral to the porus acusticus is removed using the carbon dioxide laser. Care is taken not to open the sigmoid sinus. Standard micro-otological instruments with a 2 cm extension are used (Mansfield Smith, Richards, Sturrs, V. Mueller). A lancet knife is used to identify the porus acusticus and to determine its superior and inferior limits.

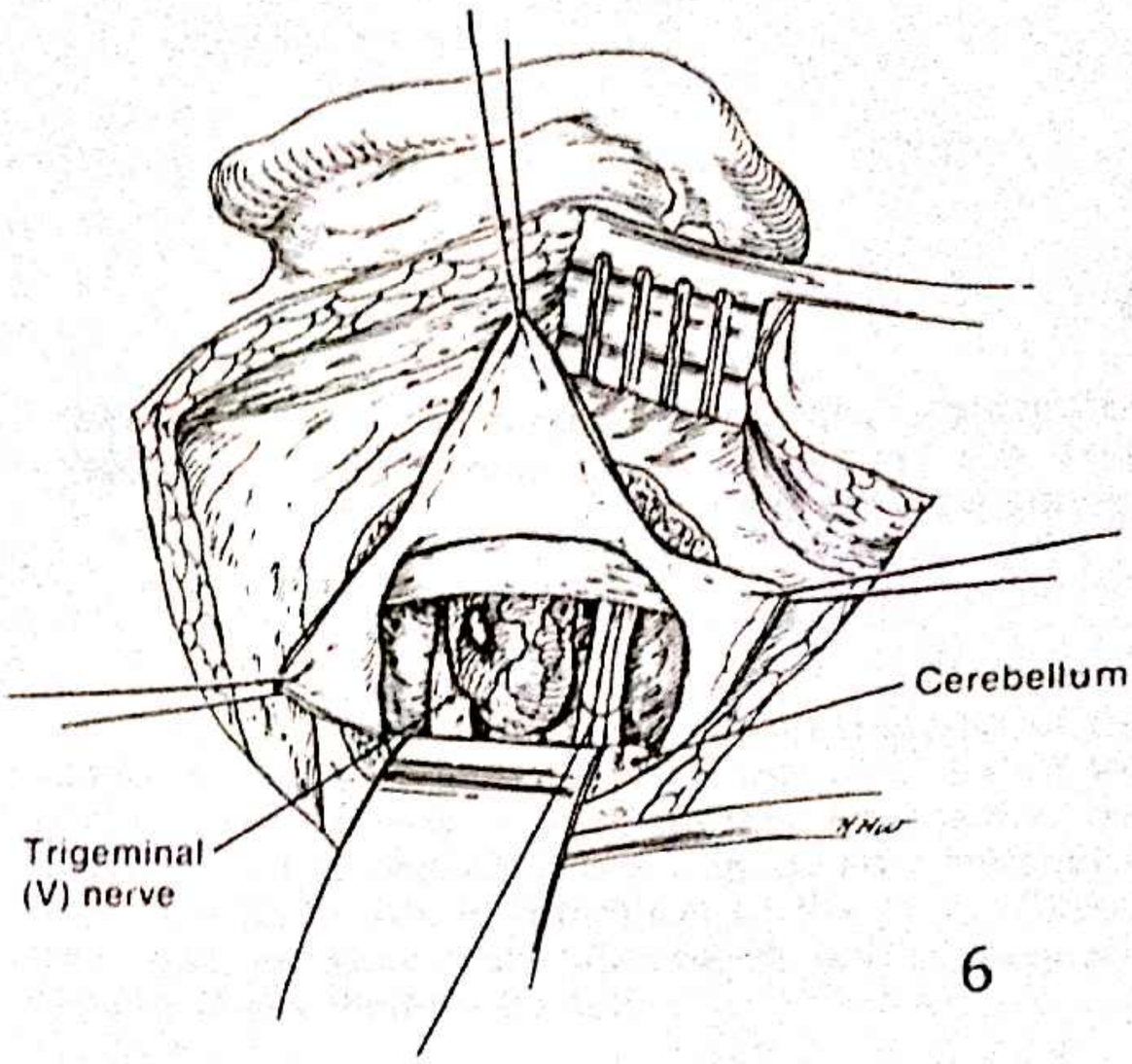
7

6

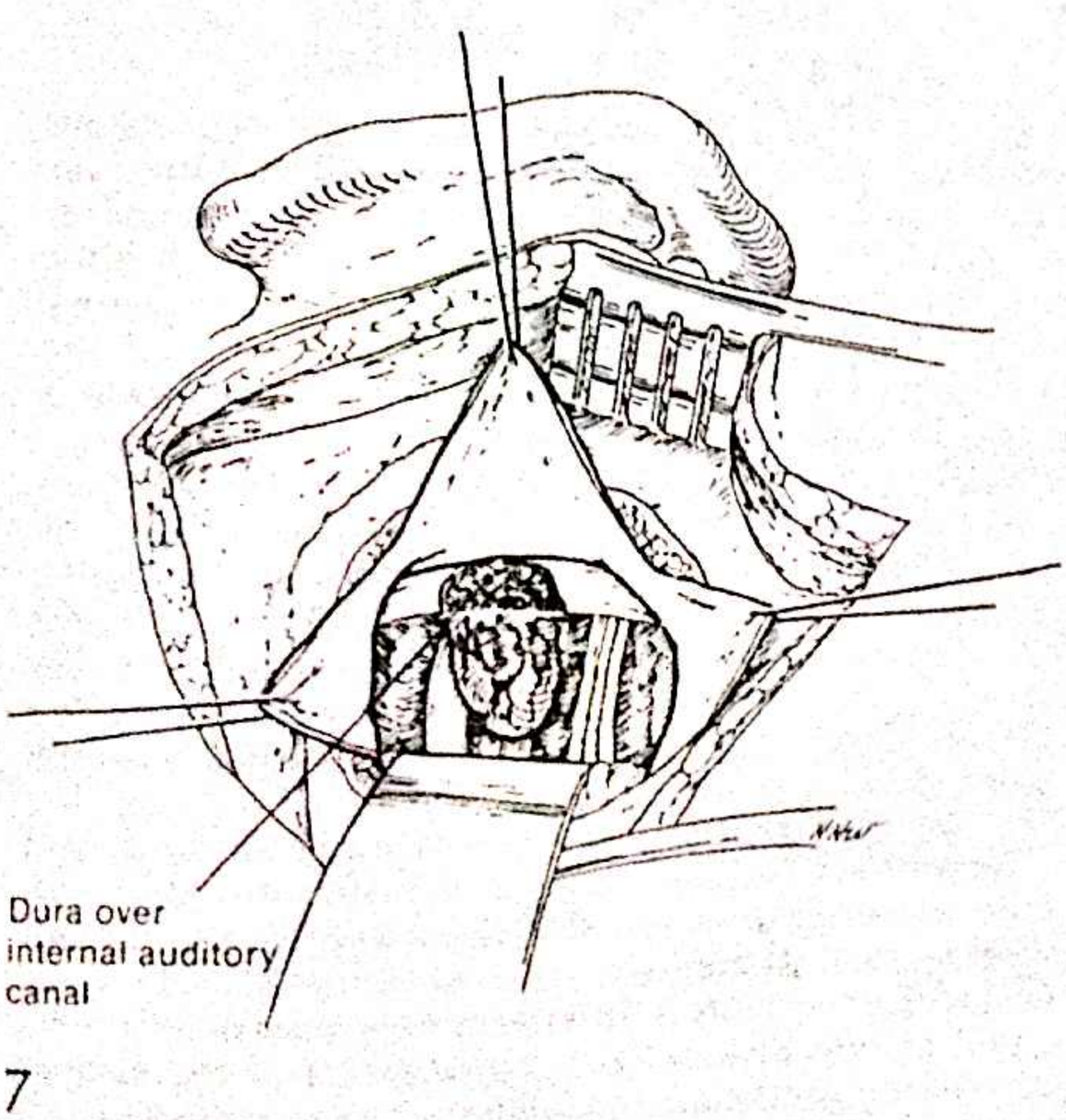
The dura is opened in a cruciate fashion and retracted with stay sutures.

Cerebellar distension may be minimized by tilting the patient 'head up' and by the use of steroids, mannitol, hyperventilation and CSF drainage.

Collagen sponge, e.g. Bicol (Codman), is placed against the cerebellum to protect it from damage. A self-retaining Leyla type retractor secured to the operating table is used for limited gentle retraction of the cerebellum. Opening the arachnoid of the cisterna magna allows prompt egress of cerebrospinal fluid and provides excellent cerebellar relaxation and exposure of the tumour with a minimum of retraction. To avoid injury to surrounding cranial nerves and brainstem blood supply, the arachnoid over the tumour must be opened, using sharp dissection. The tumour can then be exposed in the subarachnoid plane.



6



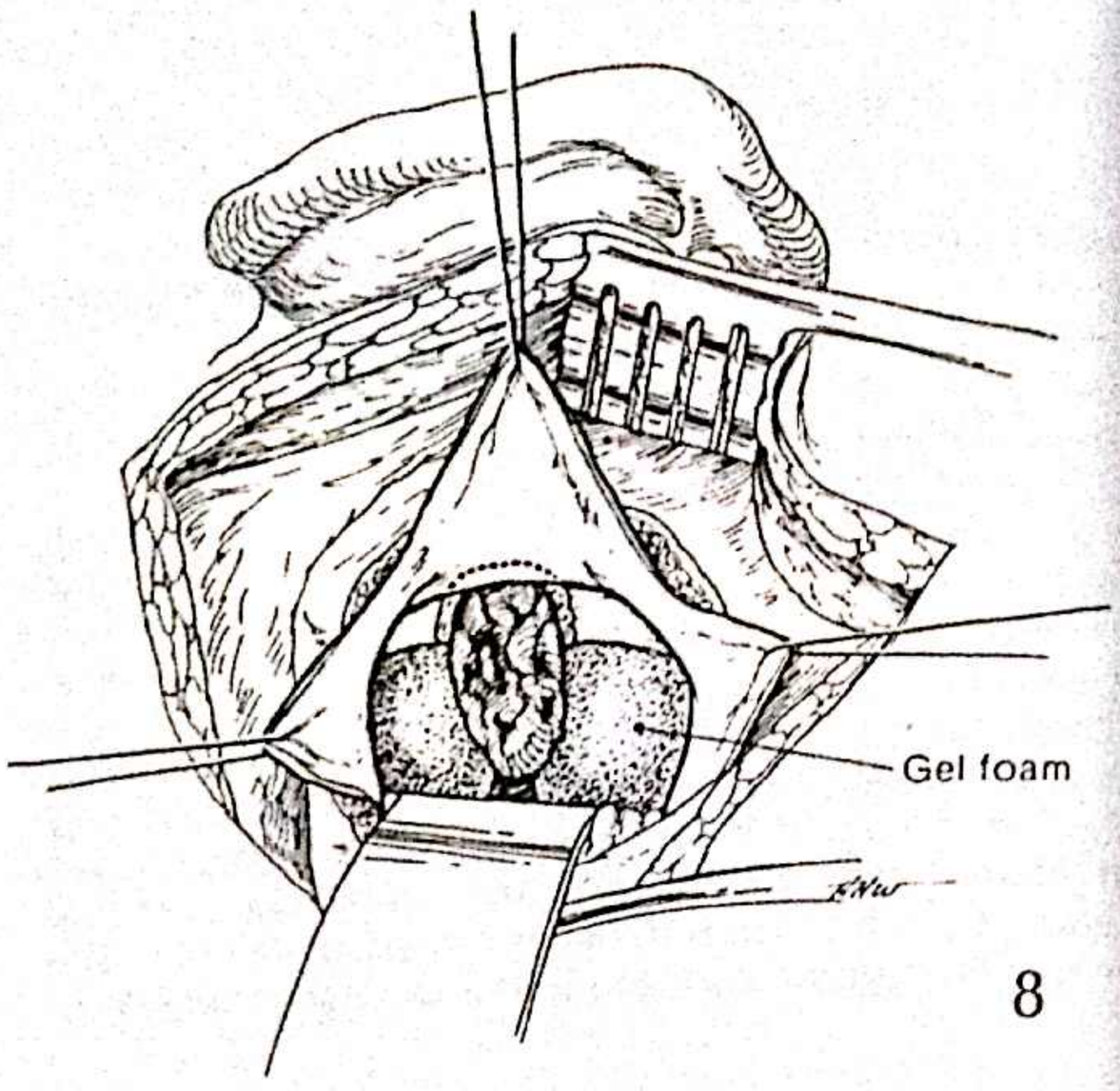
7

7

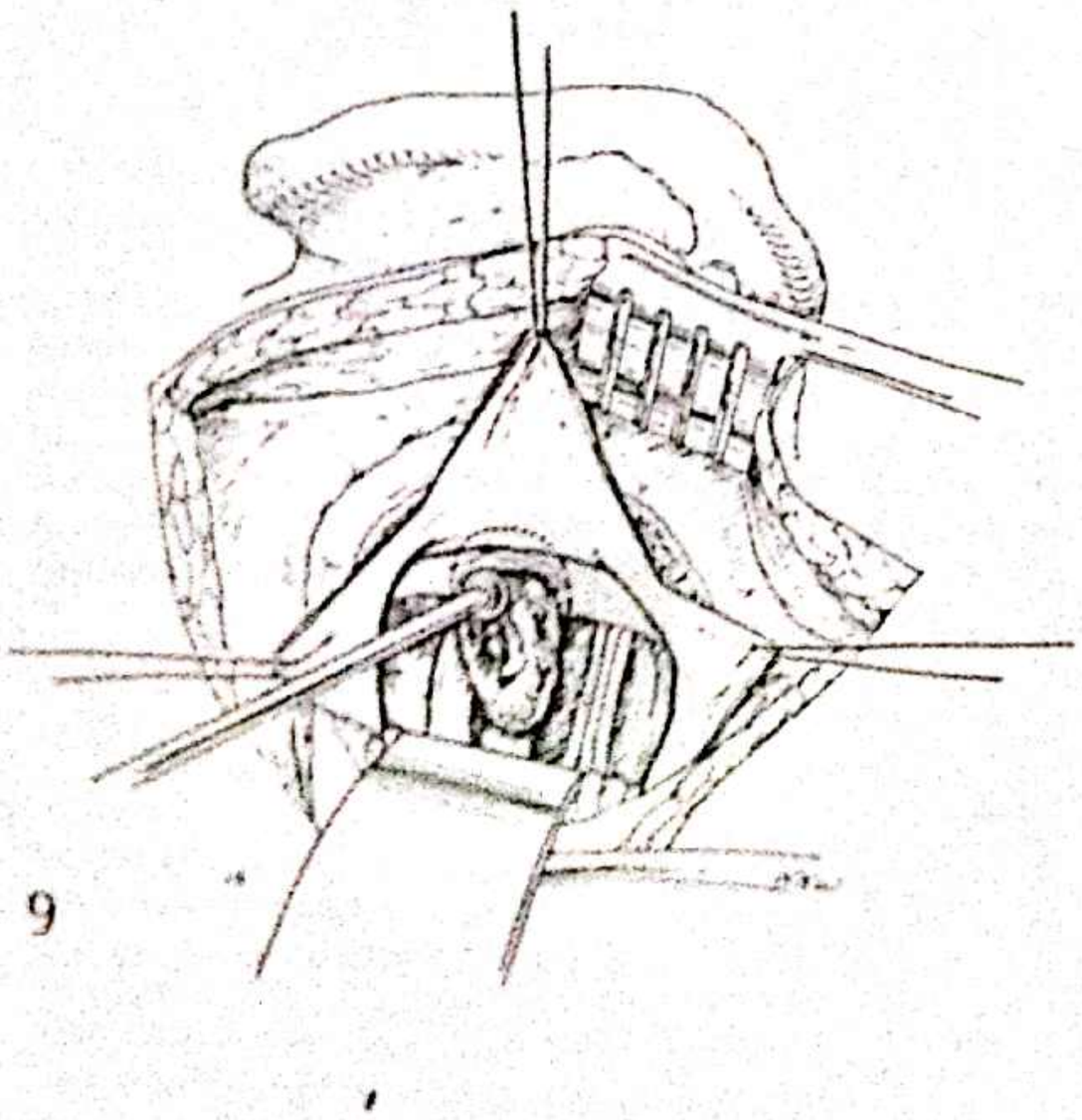
Once the posterior aspect of the tumour has been exposed, the dura (periosteum) lateral to the porus acusticus is removed using the carbon dioxide laser. Care is taken not to open the sigmoid sinus. Standard micro-otological instruments with a 2 cm extension are used (Mansfield Smith, Richards, Storrs, V. Mueller). A lancet knife is used to identify the porus acusticus and to determine its superior and inferior limits.

8

Absorbable gelatin sponge (Gelfoam) is placed above and below the tumour to prevent bone debris and blood entering from the angle.



8



9

9

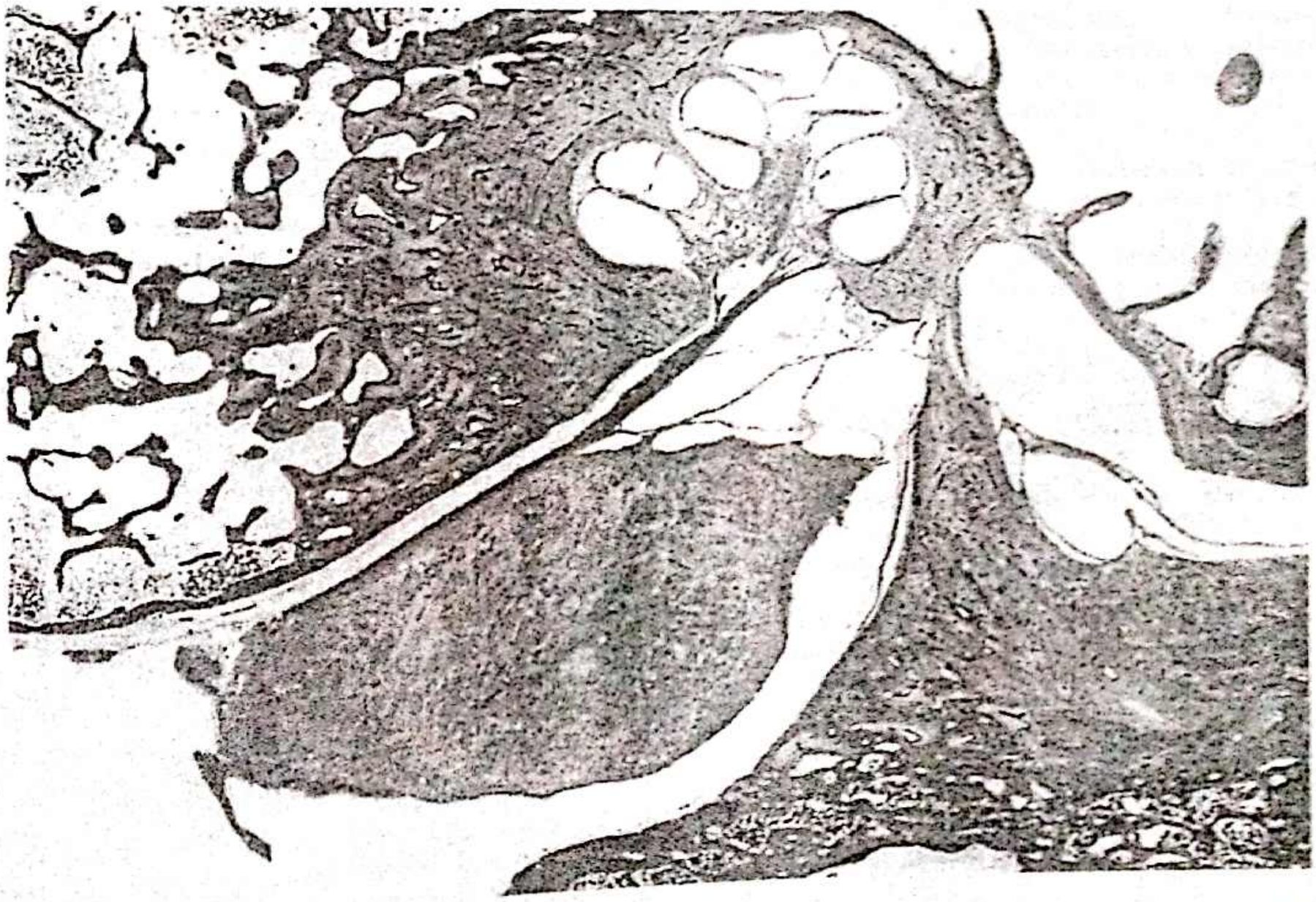
Using a high-speed microsurgical drill with appropriate burrs (Hall-Amsco) and suction-irrigation, the bone over the posterior lip of the internal auditory canal is removed. (The absorbable gelatin sponge is normally left in place until drilling is completed but has been removed from this illustration for the sake of anatomical orientation.) The contents of the canal are 'blue-lined'. Bone removal is continued laterally for approximately 8 mm, or to approximately 1.5 mm medial to the falciform crest. This crest can be palpated with the lancet knife. Bone cannot be removed beyond this point without the danger of entering the vestibule, common crus or superior semicircular canal. The foramen singulare may be violated, but this should not be a problem. Drilling is now continued in a superior-inferior direction to allow wide exposure of the tumour in the internal auditory canal.

The most important points to remember are to dissect the tumour as much as possible in a superior-inferior or inferior-superior direction and never to press the tumour anteriorly, as the anterior lip of the internal auditory canal may damage the VIIth–VIIIth nerve neurovascular bundle. Careful carbon dioxide laser vaporization of the tumour and extreme gentleness throughout the procedure, which requires ×16–25 magnification, are equally important. A multiple aperture suction tip (Brackmann) plays an important part in minimizing tissue trauma.

10

A controversial and critical area of dissection is the most lateral extension of the tumour in the internal auditory canal. Small encapsulated tumours which do not extend to the most lateral portion of the internal auditory canal (illustrated here) are particularly amenable to total removal, with maximum sparing of adjacent vascular and neural tissue.

If the tumour extends to the lateralmost aspect of the fundus or is not encapsulated, or if for some reason the operator believes that total removal is impossible, the dissection can be extended into a modified translabyrinthine approach, with identification of the vertical crest (Bill's bar), exposure of the VIIth nerve, and subsequent removal of any residual tumour.

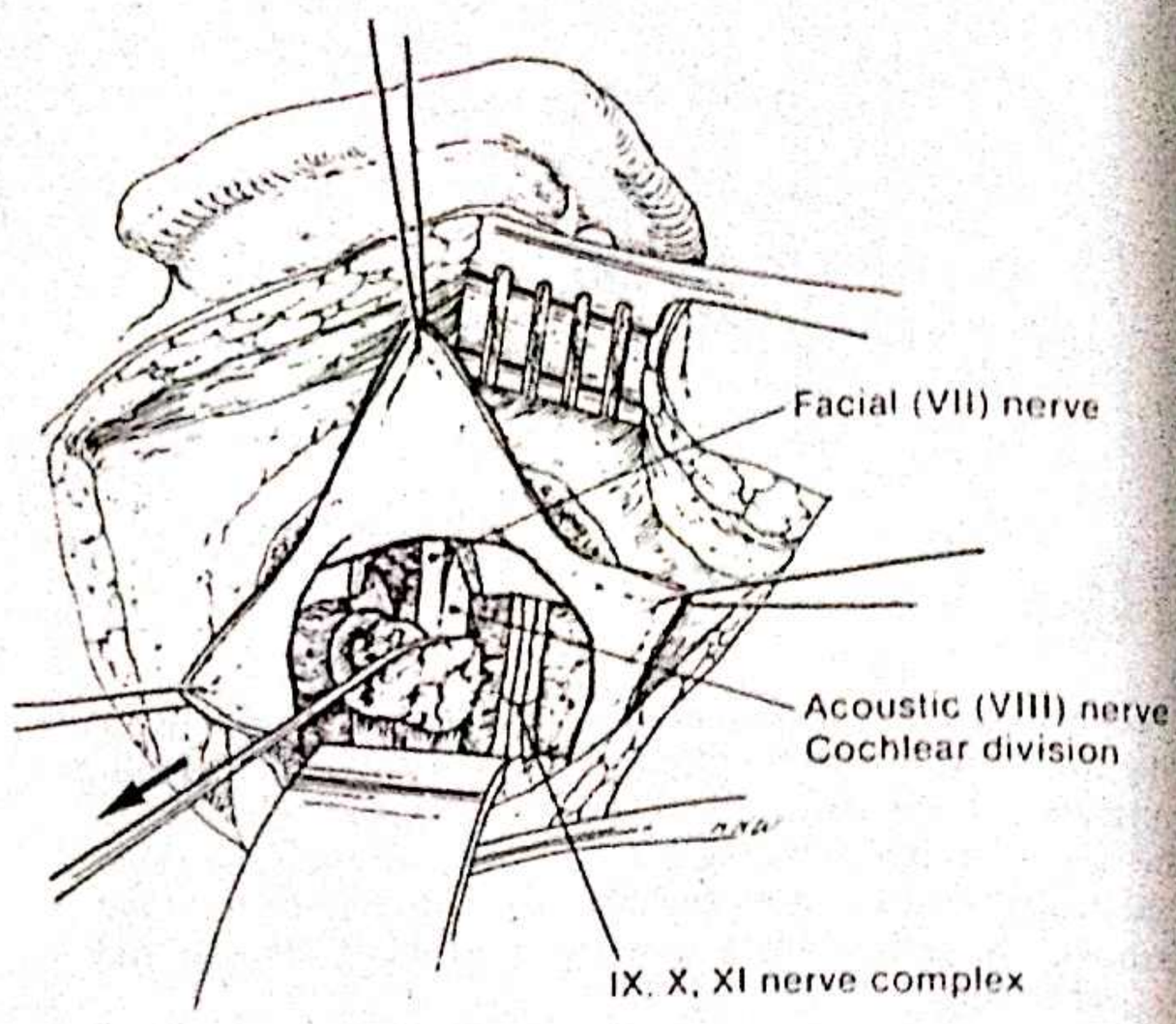


11

An encapsulated tumour that does not extend to the fundus can be dissected inferiorly, superiorly and medially through the retrosigmoid approach, which allows early and positive identification of the facial nerve.

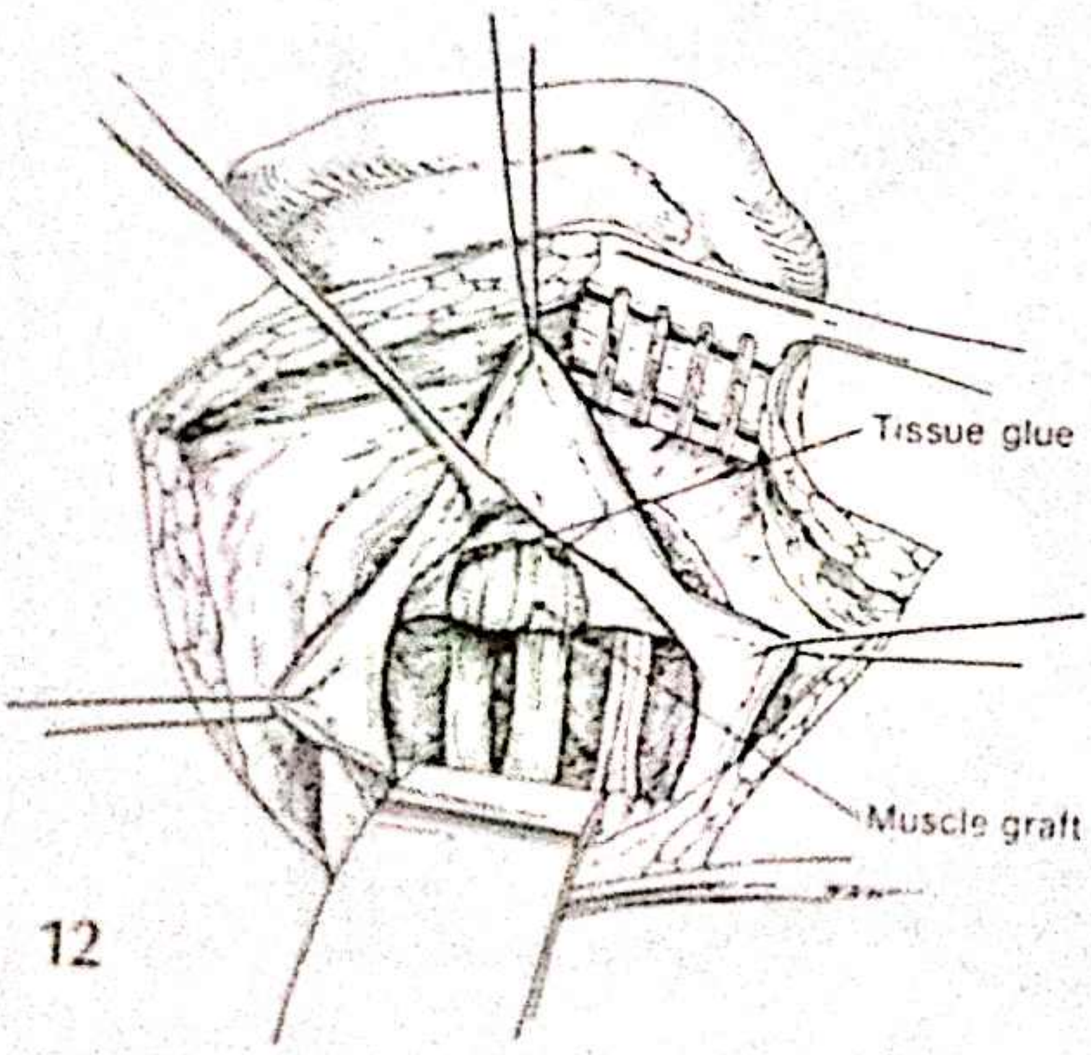
Reduction in cochlear action potential on medial traction of the VIIth–VIIIth nerve vascular bundle has been noted.

Dissection medial to the area of the porus acusticus proceeds along similar lines. A note of caution: in order to avoid overheating, the laser should only be used for short periods and at low wattage. Constant irrigation with Ringer's lactate at body temperature is essential. Bleeding points are coagulated by laser, or by bipolar electrocautery. Occasionally a microclip may be used.



11

Closure



12

12

The craniotomy wound is irrigated to remove as much blood, bone dust and absorbable gelatin sponge as possible. All mastoid air cells are sealed with bone wax, and if there are large petrous apical cells these are opened and filled with muscle taken as an autograft from the craniotomy site. A piece of muscle that will fill the internal auditory canal defect is positioned and secured with tissue glue, e.g. Histocryl.

If a complete mastoidectomy is performed the mastoid and dura areas are lined with freeze-dried infant dura, and the defect is filled with abdominal fat. The lining is used to prevent the fat from exuding into the middle ear space and producing a potential conductive hearing loss. Because infant dura is thin it adapts well to the irregularities of osseous mastoid defects.

The dura can be left open and the dural incision covered with oxidized regenerated celluiose (Surgicel) to allow unimpeded postoperative cerebellar oedema. Fastidious closure of both the muscular and galeal layers is important to avoid postoperative CSF leakage through the wound.

Postoperative care

Any postoperative weakness or paralysis of the VIIth nerve is treated by:

1. Artificial tears (3 drops every hour during waking hours) in the eye on the affected side;
2. Ophthalmic ointment on the lower lid at bedtime (and repeated as often as necessary during the waking state if the patient complains of burning or if any redness is noted in the eye);
3. Taping the upper lid horizontally with a slight inferior pull laterally, while the lower lid is pulled laterally and superiorly. Tincture of benzoin is used to protect the upper and lower lid skin and also helps to keep the tapes (¼ inch Steri-Strips) in place. Eye patches or tape across the eyelid should not be used because of the possibility of causing corneal abrasion, particularly when there is Vth and VIIth nerve involvement.

Patients with complete or partial facial paralysis are given instructions for home care and advice on how to protect the eye.

Results

In a series of 100 consecutive patients with acoustic neurilemmoma, 23 had small tumours, 15 mm or less, medial to the porus acusticus. Eight of these patients had a speech discrimination score of 80 per cent or more and 4 of these 8 retained hearing at the preoperative level.

Complications are unusual during or following the retrosigmoid approach for removal of small lesions involving the internal auditory canal but not extending to the brainstem. Of the 23 patients with acoustic neurilemmomas extending 15 mm or less into the angle, 2 developed CSF leaks and 1 a non-communicating hydrocephalus. One of the two patients with a leak required re-operation, at which a large petrous apical cell was found; this was drilled out and filled with muscle, stopping the leak. The other was managed by lumbosacral CSF drainage (for 3 days), acetazolamide (Diamox) and elevation of the head. The patient with hydrocephalus required a shunt. The hydrocephalus was probably the result of blood and bone dust spreading beyond the site of dissection. This can be prevented by damming the area of the angle (*see earlier*), by careful attention to haemostasis, and by *constant* irrigation, particularly during drilling of the posterior lip of the internal auditory canal.

None of the 23 patients with small tumours (15 mm or less) suffered long-term facial paralysis. However, postoperative facial nerve function is notoriously difficult to predict since some neurilemmomas originate in or invade the VIIth nerve, making its preservation impossible. Furthermore, despite improvements in exposure and instrumentation, the risk of injury to the VIIth nerve remains. The nerve should be identified as soon as possible and protected throughout the course of the dissection.

Conclusions

Preservation of hearing in acoustic neurilemmoma surgery via the retrosigmoid approach is possible in approximately 50 per cent of patients with tumours measuring 15 mm or less in site and speech discrimination scores of 80 per cent or more.

Conservation of hearing is also possible if the tumour is larger than 15 mm (measured medial to the porus acusticus), but the likelihood of success decreases markedly as the tumour approaches the brain stem.

Acknowledgements

Originally published as 'Hearing conservation in acoustic neurilemmoma surgery via the retrosigmoid approach' in Rand, R. W. Microneurosurgery, 3rd edn., 1985. The C. V. Mosby Co, St Louis, USA.

Illustration 10 is reproduced by kind permission of Professor Harold Schuknecht, Massachusetts Eye and Ear Infirmary, Boston, Massachusetts, USA.

References

1. Bremond, G., Garcin, M., Magnan, J. Preservation of hearing in the removal of acoustic neuroma. Minimal posterior approach by retrosigmoidal route. Journal of Laryngology and Otology 1980; 94: 1199–1204

2. Cohen, N. L. Acoustic neuroma surgery with emphasis on preservation of hearing. Laryngoscope 1979; 89: 886–896

3. Cohen, N. L., Ransohoff, J. Hearing preservation–posterior fossa approach. Otolaryngology–Head and Neck Surgery 1984; 92: 176–183

4. Fischer, G., Costantini, J. L., Mercier, P. Improvement of hearing after microsurgical removal of acoustic neurinoma. Neurosurgery 1980; 7: 154–159

5. Smith, M. F., Lagger, R. L. Hearing conservation in acoustic neurilemmoma surgery via the retrosigmoid approach. Otolaryngology–Head and Neck Surgery 1984; 92: 168–175

6. Smith, M. F. W., Clancy, T. P., Lang, J. S. Conservation of hearing in acoustic neurilemmoma excision. Transactions of the American Academy of Ophthalmology and Otolaryngology 1977; 84: 704–709

7. Sterkers, J. M. Removal of bilateral and unilateral acoustic tumours with preservation of hearing. In: Neurological Surgery of the Ear, Vol. 2, pp. 269–277. Birmingham, Alabama: Aesculapius Publishing Company, 1979

8. Brackmann, D. E. Middle cranial fossa approach. In: House, W. F., Luetje, C. M. eds. Acoustic Tumours, Vol. 2. Management, pp. 15–41. Baltimore, University Park Press, 1979

9. Glasscock, M. E. III, Dickens, J. R. E., Wiet, R. J. Preservation of hearing in acoustic tumour surgery middle fossa technique. In: Neurological Surgery of the Ear, Vol. 2, pp. 284–286. Birmingham, Alabama: Aesculapius Publishing Co., 1979

10 Wade, P. J., House, W. Hearing preservation in patients with acoustic neuromas via the middle fossa approach. Otolaryngology–Head and Neck Surgery 1984; 92: 184–193

Illustrations by Patrick Elliott and Ivan Glitsch

The middle fossa approach to the internal auditory meatus

U. Fisch MD
Professor and Head, Ear, Nose and Throat Department, University Hospital, Zürich, Switzerland

Introduction

The middle fossa approach or – as we prefer to call it – the transtemporal supralabyrinthine approach is one of the basic and essential accesses to the skull base. It affords the only possible way to expose the meatal and labyrinthine segments of the facial nerve while preserving hearing in cases of longitudinal fractures of the temporal bone, of cholesteatoma and of tumours involving the facial nerve in the supralabyrinthine region. The transtemporal, supralabyrinthine approach also allows the selective resection of the meatal segment of the vestibular nerve (including Scarpa's ganglion) in a place where cochlear and vestibular nerve fibres naturally separate and where the danger of a possible complication is minimized by the small size of the surrounding vessels.

If properly performed the transtemporal supralabyrinthine approach is not fraught with more complications than extensive mastoid surgery. The surgical principle that has to be followed is to gain adequate access towards the internal auditory canal by removing bone from the roof of the pyramid rather than be elevating the middle fossa dura away from it. The prerequisites for successful exposure of the internal auditory meatus via the supralabyrinthine bone are quite different from those required for middle ear procedures. Absolute sterility, thorough knowledge of the temporal bone anatomy from a completely different angle of view, and solid training in otoneurosurgical techniques are necessary for the safe performance of the surgical techniques described in this chapter.

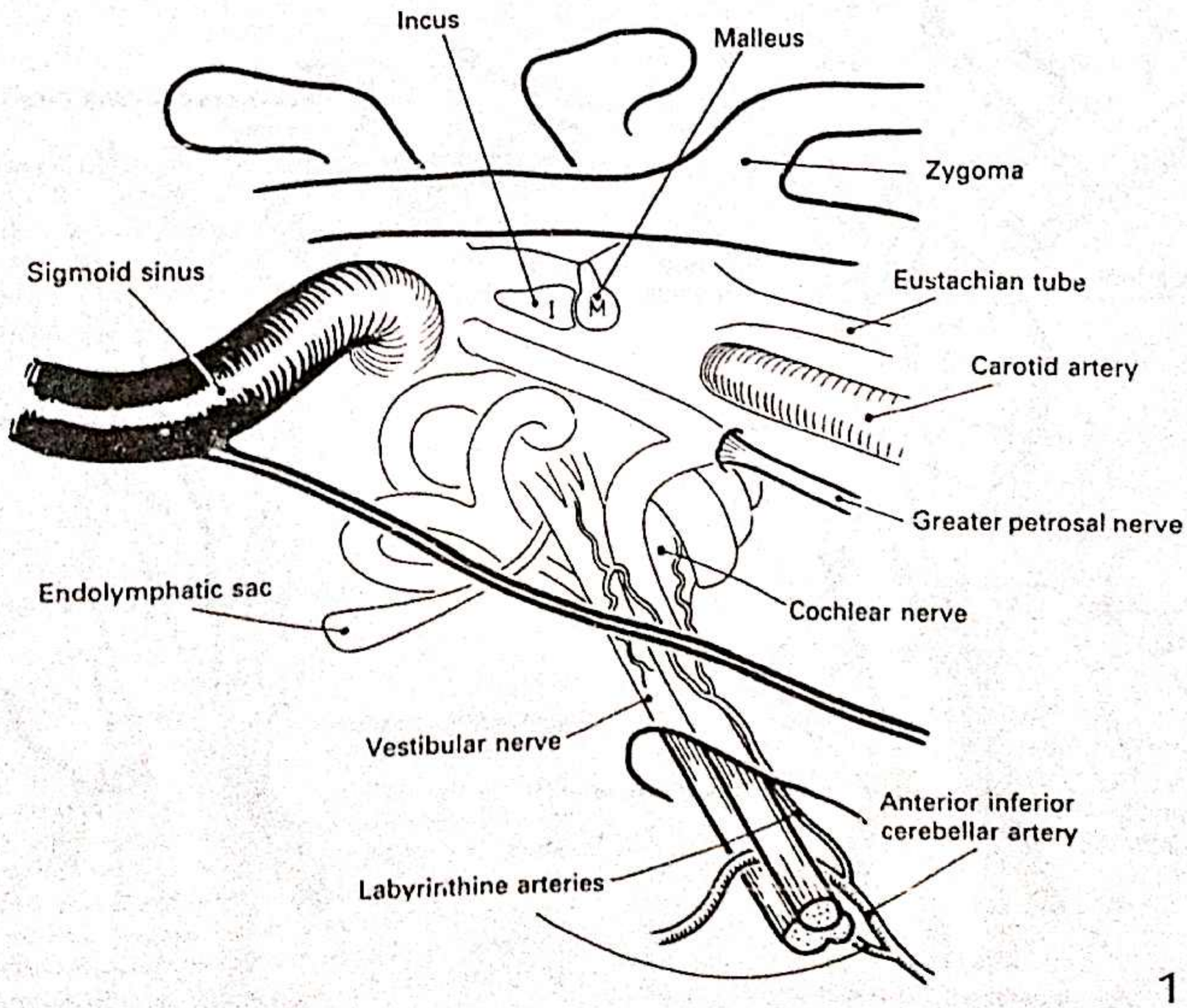
Surgical anatomy

1

Temporal bone as viewed from the base of the middle cranial fossa

The middle fossa approach to the internal auditory canal requires precise anatomical knowledge of the structures underlying the bony surface of the temporal bone, as damage to the inner ear spaces, the facial nerve and the superior petrosal sinus must be avoided under all circumstances. The roof of the middle ear should also be respected in order to avoid lesions to the ossicular chain, either through the surgery itself or through postoperative compression of the dura.

The most important surgical landmark at the base of the middle cranial fossa is the superior semicircular canal. This can be easily identified by skeletonizing the compact labyrinthine bone from the surrounding pneumatic bone in the region of the arcuate eminence. It has to be remembered that the superior semicircular canal does not lie exactly under the arcuate eminence but is usually slightly anterior to it. Identification of the superior semicircular canal is essential to determine the position of the internal auditory canal (*see Illustration 14*). The facial hiatus and the greater superficial petrosal nerve are also useful landmarks, as they indicate the position of the external genu of the facial nerve and of the basal turn of the cochlea, which is situated just beneath this last structure. The superior semicircular canal posteriorly and the facial hiatus anteriorly define the meatal plane, i.e. the segment of bone which has to be removed in order to reach the internal auditory canal. Opening of the tegmen tympani is necessary if the facial nerve is to be exposed in its entire tympanic portion from above. The opening has to be reconstructed with a fragment of the craniotomy flap at the end of the procedure. Elevation of the dura should stop medially at the superior petrosal sulcus. By so doing we have consistently been able to avoid damage to the superior petrosal sinus. Exposure of the middle meningeal artery is not necessary for surgery limited to the internal auditory canal region.



1

2

Arterial system of the internal auditory canal

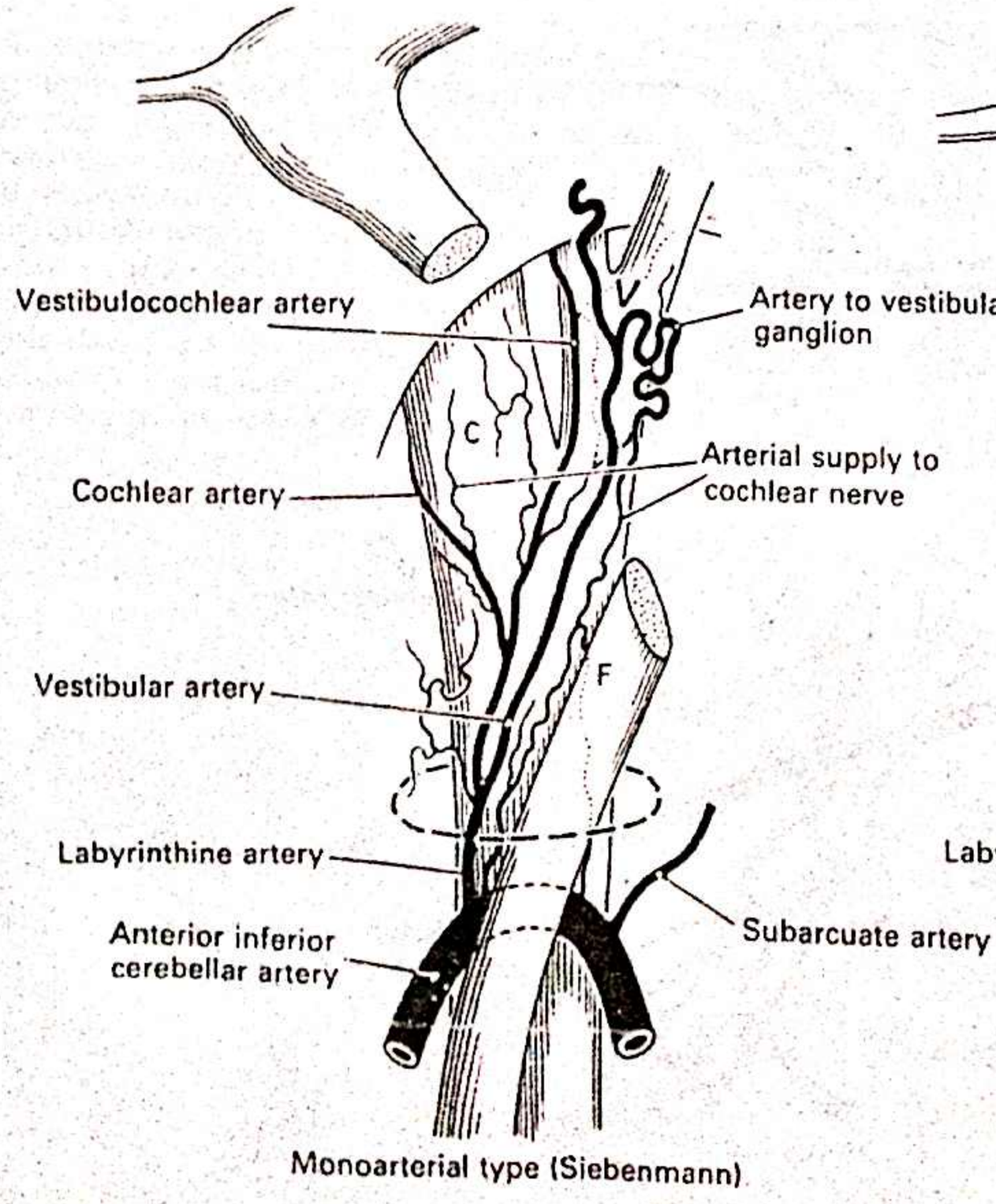
Knowledge of the vascular anatomy of the internal auditory canal is an essential prerequisite for selective intrameatal surgery on the vestibular, cochlear and facial nerves with preservation of hearing. According to the number of labyrinthine arteries, two types of arterial pattern are observed. In 45 per cent of cases only a *single labyrinthine artery* penetrates into the internal auditory canal. Its ramifications follow (with minor variations) the pattern described by Siebenmann in 1894, giving rise to the *vestibular artery*, the *vestibulocochlear artery* and the *true cochlear artery*. The remaining 55 per cent of cases have two *labyrinthine arteries* whose pattern of ramification is similar to that described by the Russian Konaschko in 1927. It differs from the former insofar as the second labyrinthine artery (also called *posterior vestibulocochlear artery*) replaces in its distribution the *vestibulocochlear artery* of Siebenmann.

The labyrinthine artery (or arteries) always enters the internal auditory canal at the anterior inferior rim of the porus. In the monoarterial type the labyrinthine vessel lies between the cochlear and facial nerves. In the biarterial type one vessel (the superior) takes the same course as the single labyrinthine artery, giving origin to a cochlear and a vestibular branch. The other vessel (the inferior) goes along the bottom of the internal auditory canal, crosses the cochlear nerve at its inferior surface and follows the inferior branch of the vestibular nerve towards the inferior vestibular area of the meatal fundus. The *true cochlear artery* always runs in the anterior half of the meatus along and around the cochlear nerve.

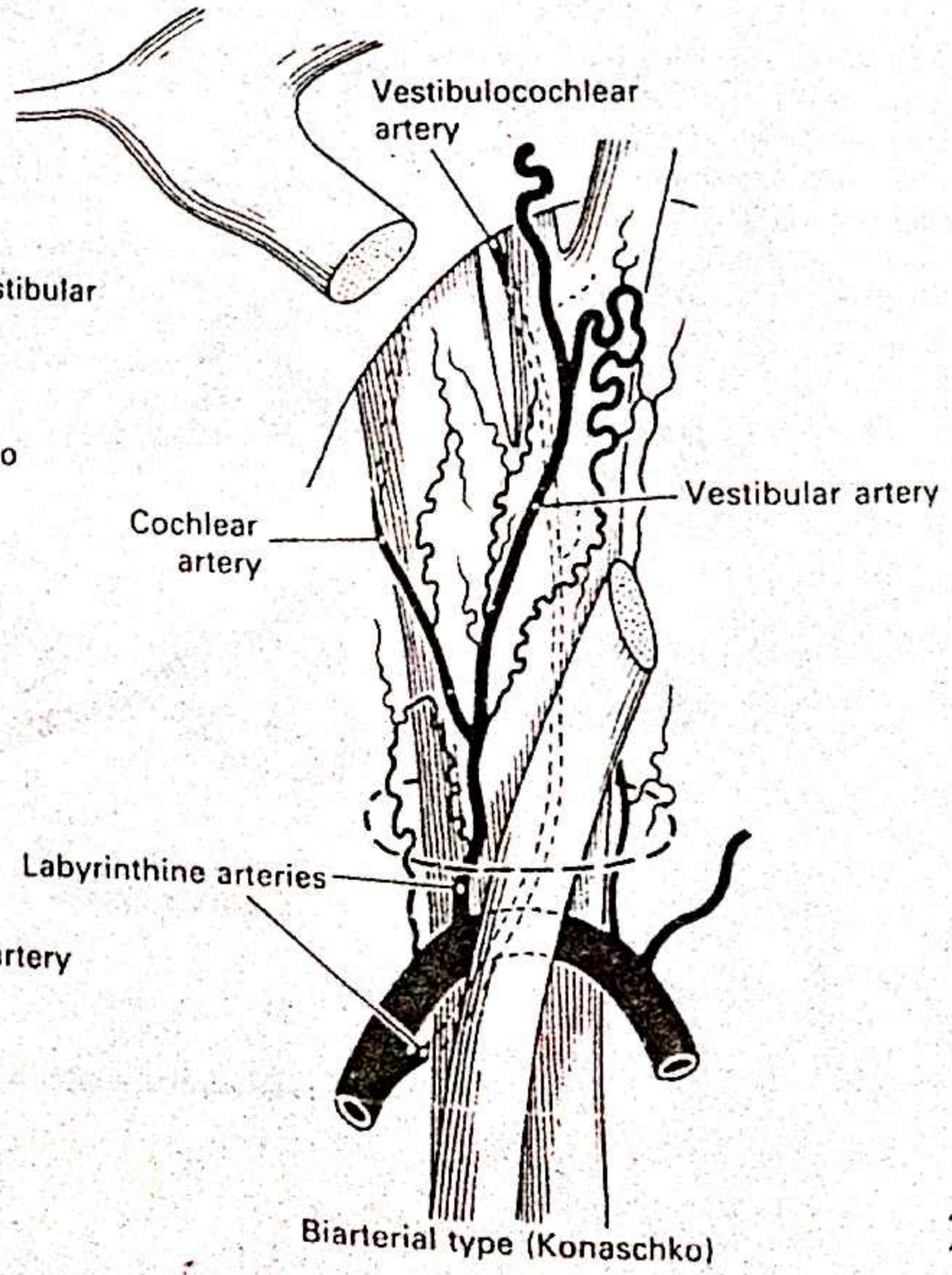
The diameter of the arteries penetrating the internal auditory meatus does not exceed 150–200 μ. The largest arterial vessel of the internal auditory canal not primarily concerned with the blood supply of the inner ear is a branch given off by the superior vestibular artery to the region of the vestibular ganglion. This artery forms numerous glomerula-like convolutions around the superior vestibular ganglion, receives anastomotic branches from the inferior vestibular artery and other vessels lying in the posterior inferior aspect of the internal auditory canal, and also provides smaller rami for the facial nerve. It is of particular surgical importance because it is the first vessel visualized in the meatus in the course of a middle cranial fossa approach.

Besides the labyrinthine artery (or arteries) a variable number (2–12) of other vessels enter the porus without reaching the inner ear. These supply the structures lying in the meatus itself (cochlear, vestibular and facial nerves, dura and bone surrounding the internal auditory canal).

In view of the complexity of the arterial system of the internal auditory canal the term 'internal auditory artery' should not be used. This name was, in fact, removed from the official anatomical nomenclature as early as 1955 in order to avoid confusion with cerebral vessels not primarily involved in the blood supply of the inner ear.



Monoarterial type (Siebenmann)



Biarterial type (Konaschko)

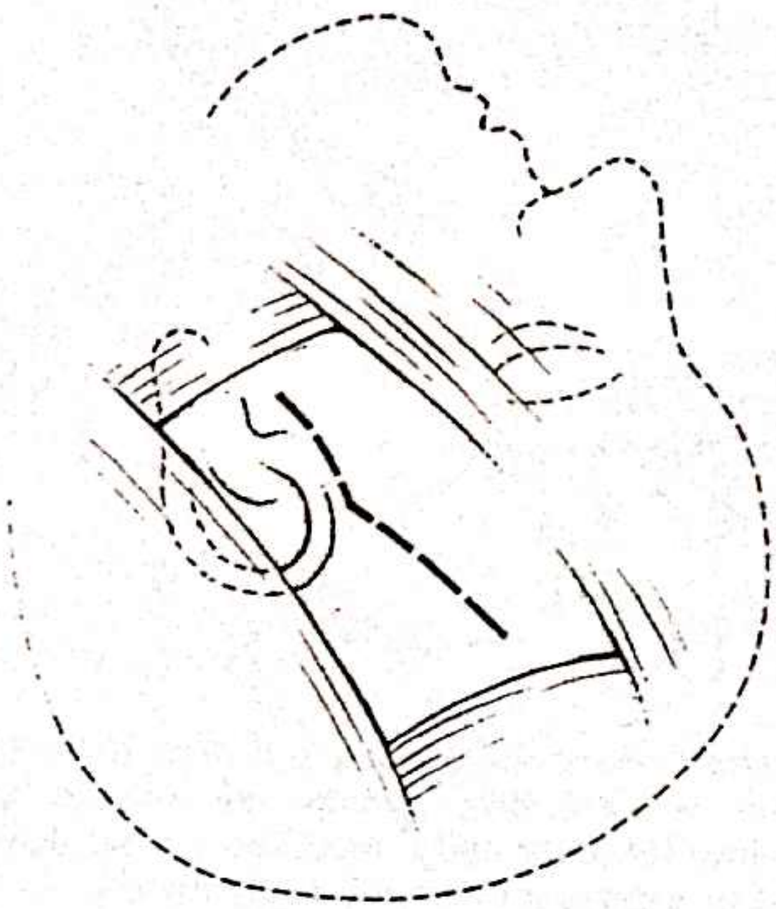
Preoperative

Anaesthesia

Premedication is usually given 1.5 hours before the operation by a single intramuscular injection. In the average adult this contains 1.5 ml Thalamontal – a combination of fentanyl and droperidol and 0.5 mg atropine. After induction with Pentothal (thiopentone sodium) and oral endotracheal intubation the anaesthesia is continued by inhalation of a mixture of oxygen and nitrous oxide, and halothane.

PREPARATION OF PATIENT

The temporal region is shaved the night before surgery. The prepared area is treated with chlorhexidine gluconate and covered with a bandage overnight. The surgical field is disinfected with Merfen before starting the operation.



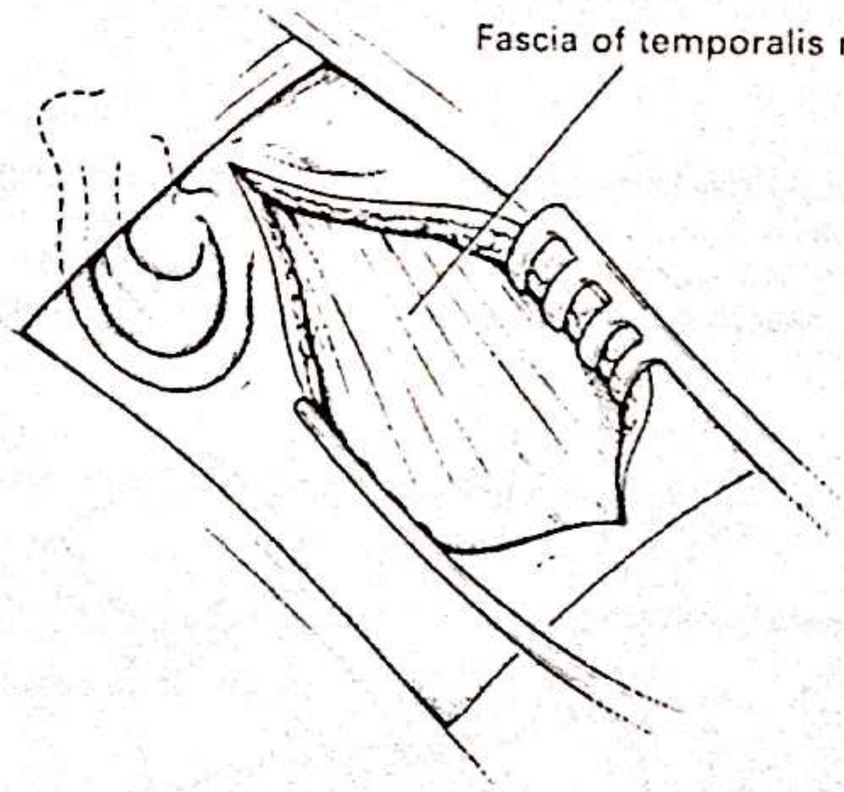
3

The approach

3

Position of patient and skin incision

The patient is placed in the supine position with the head turned to the side. The surgeon is seated at the top end of the table. The skin incision is carried along the anterior attachment of the pinna, and in a superior–anterior direction, for about 7 cm, from the root of the zygoma to the superior margin of the temporalis muscle.



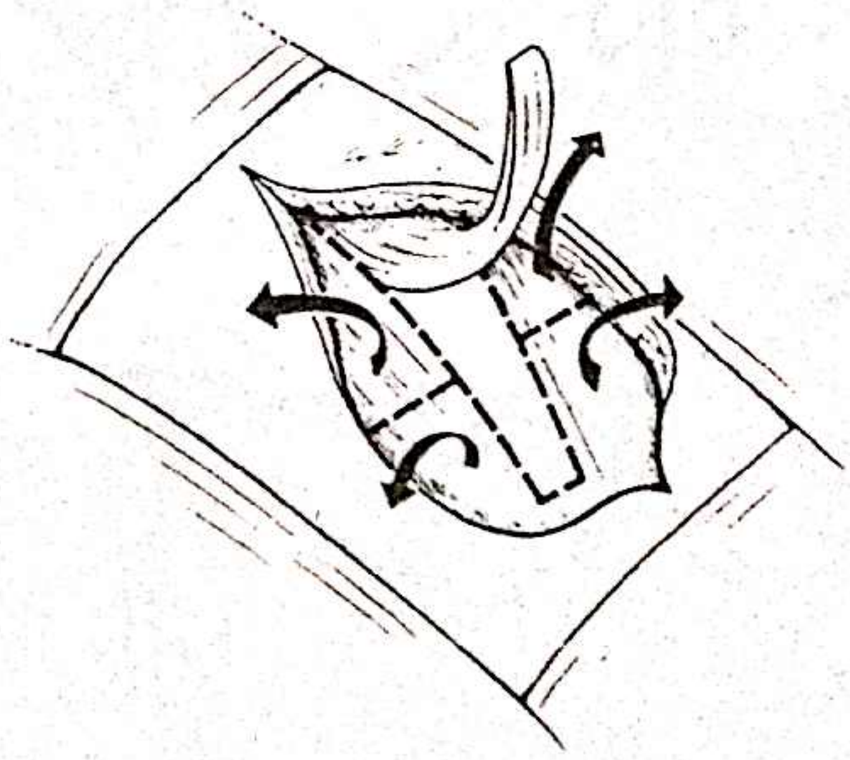
4

4

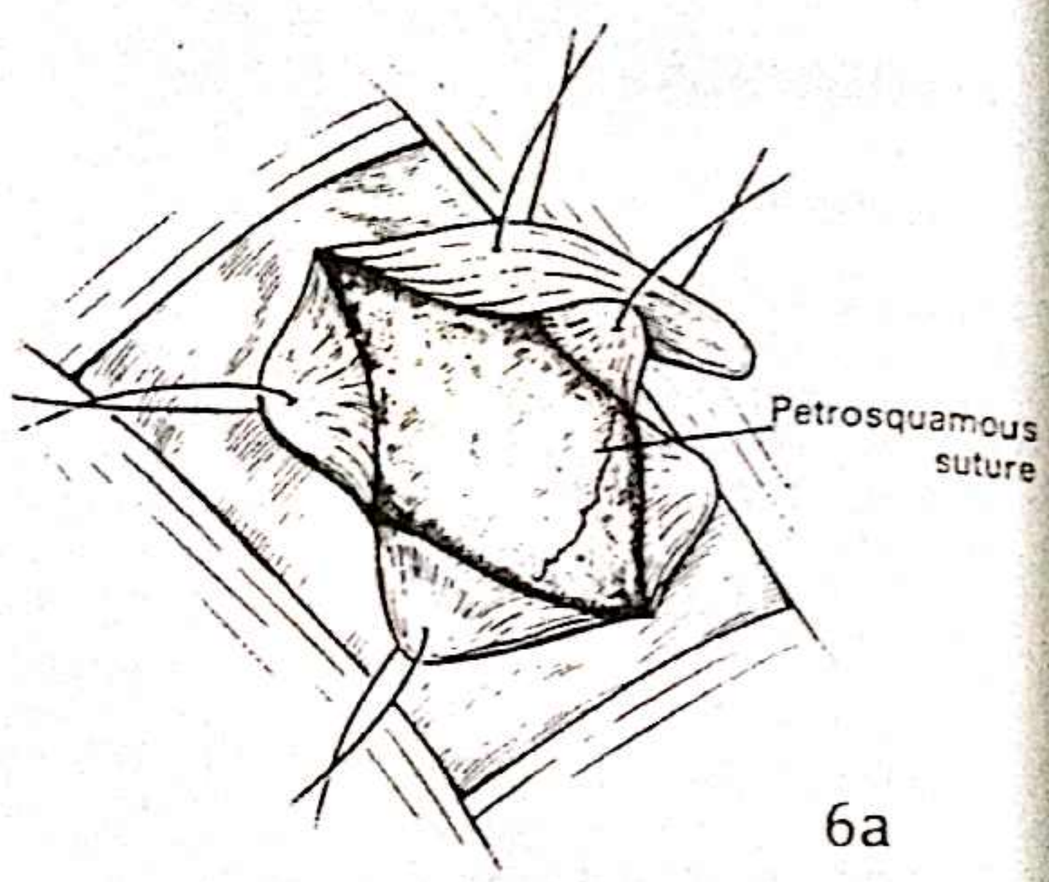
The incision is carried down to the temporalis fascia, which is then exposed by blunt dissection.

5

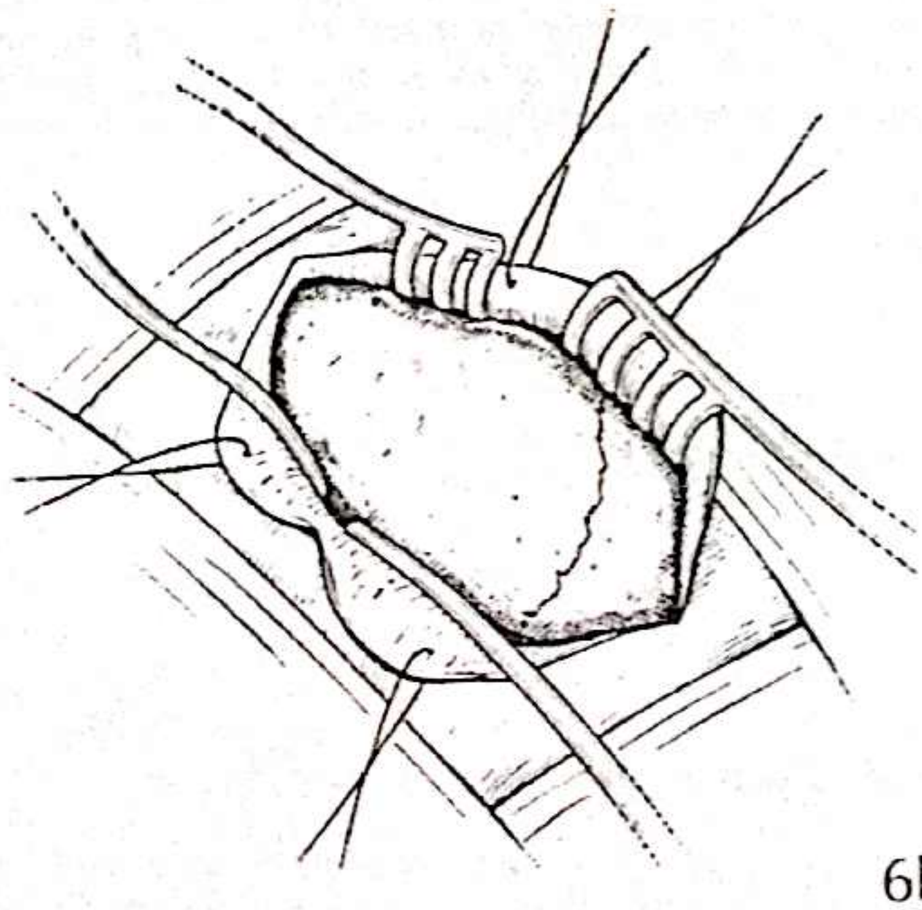
An anteriorly pedicled flap is cut into the temporalis muscle. This flap will be rotated over the internal auditory meatus at the end of the procedure. Its function is to fill the gap created by the elevation of the dura in the lateral portion of the middle cranial fossa. Two additional side incisions are made into the temporalis muscle in order to facilitate exposure of the squamous part of the temporal bone.



5



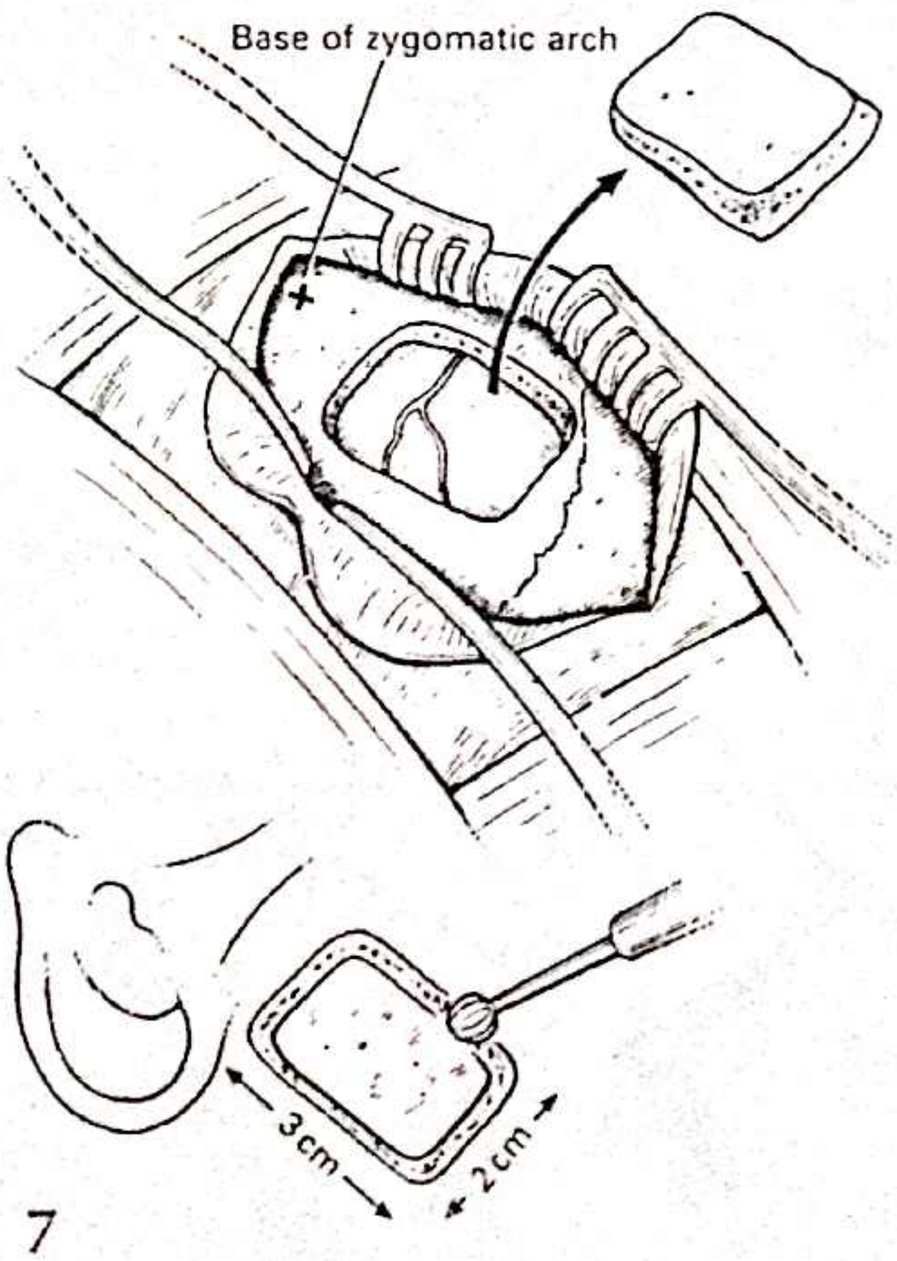
6a



6b

6a & b

The five temporalis muscle flaps are then fixed to the surrounding surgical drapes with silk sutures (*a*). A thyroidectomy retractor and a modified ear retractor are introduced to expose the temporal squama (*b*).



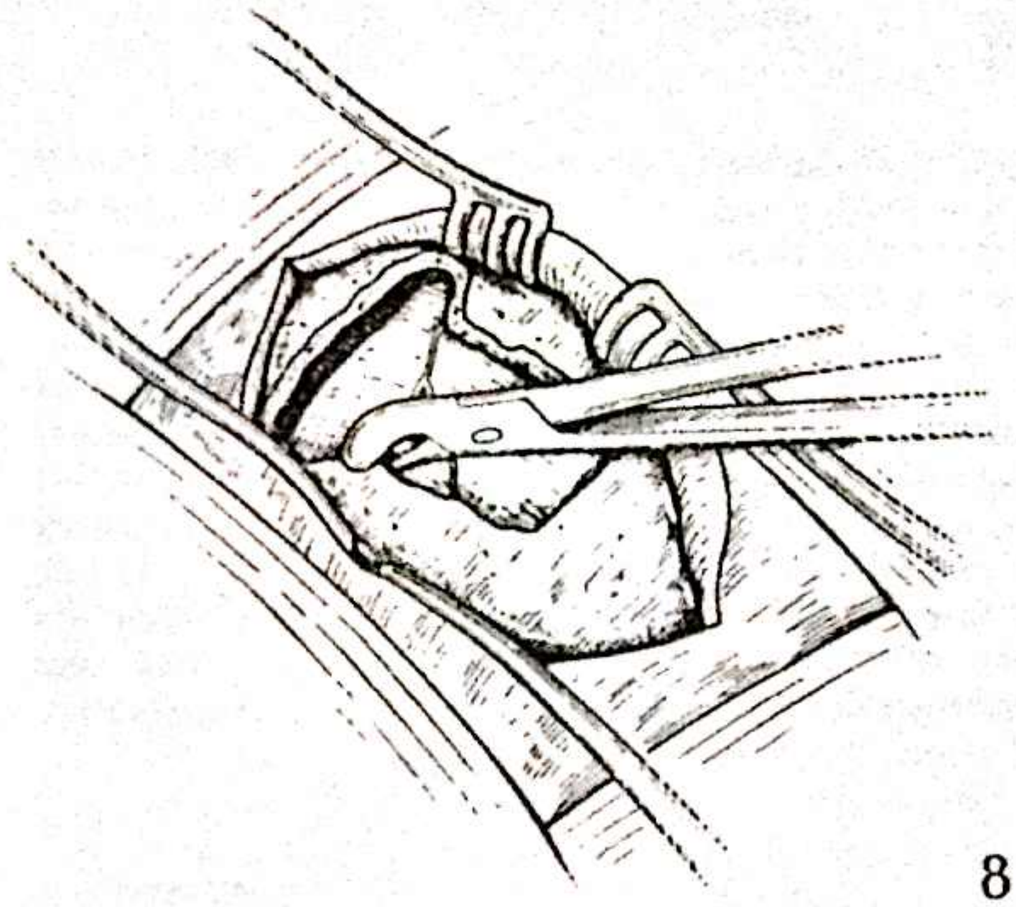
7

7

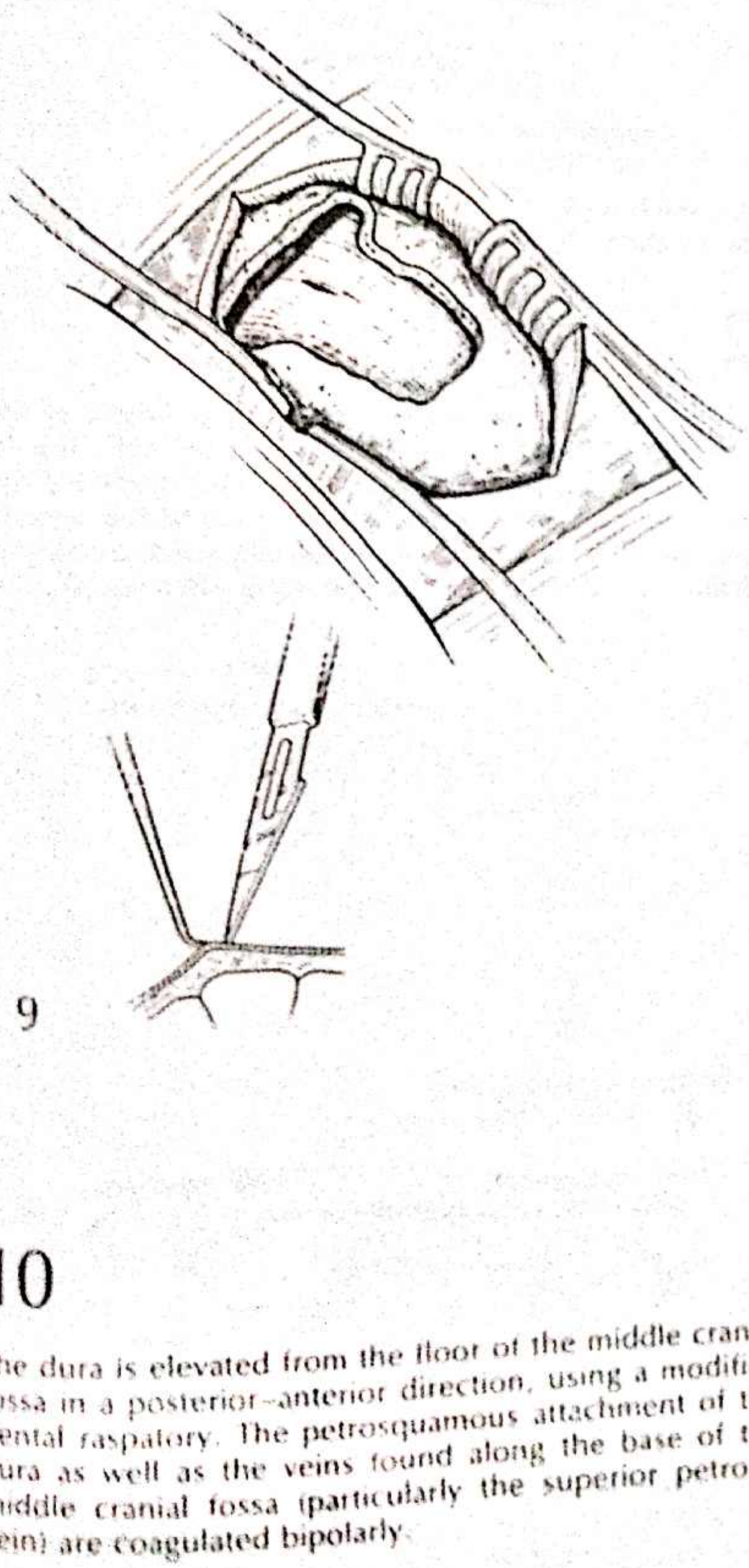
Using a cutting drill and suction-irrigation, a craniotomy opening measuring 2 cm × 3 cm is made, centred over the base of the zygomatic arch.

8

The inferior edge of the craniotomy is extended with rongeurs to reach the level of the middle cranial fossa. The craniotomy opening is extended anteriorly and posteriorly in order to allow a good view of the petrosquamous attachment of the dura and the numerous veins running between dura and bone in the anterior and posterior corners of the exposure.

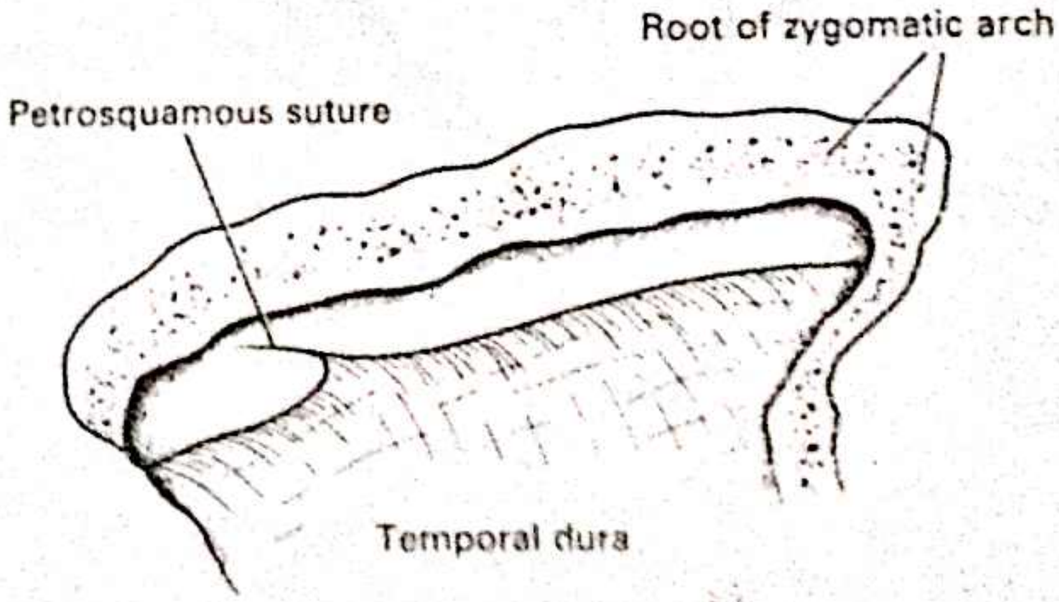


8



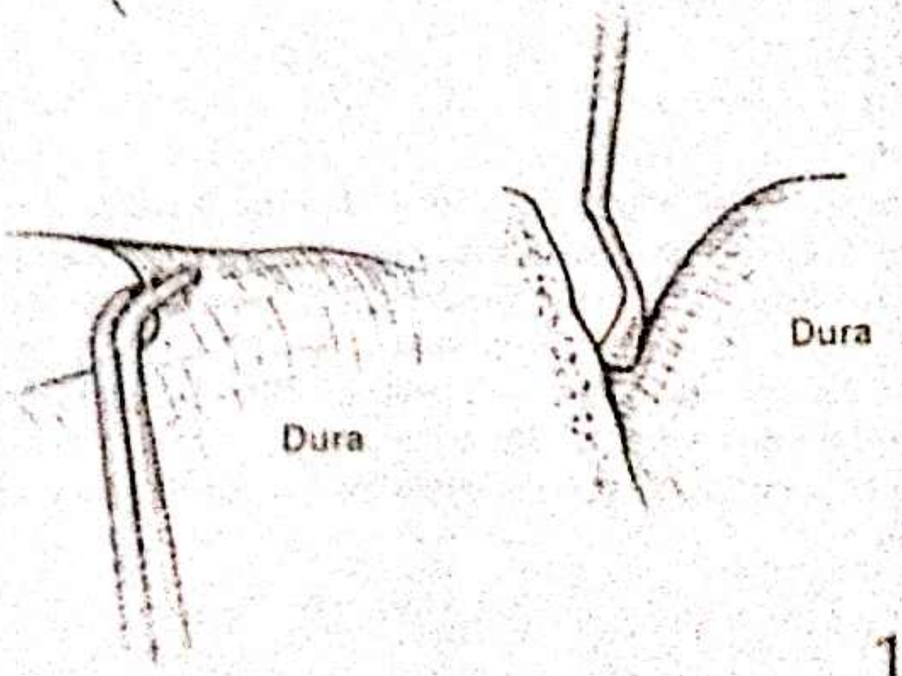
9

The dura is raised with a hook and incised with a knife in order to drain the cerebrospinal fluid over the temporal lobe. This facilitates retraction of the temporal lobe for exposure of the floor of the middle cranial fossa.



10

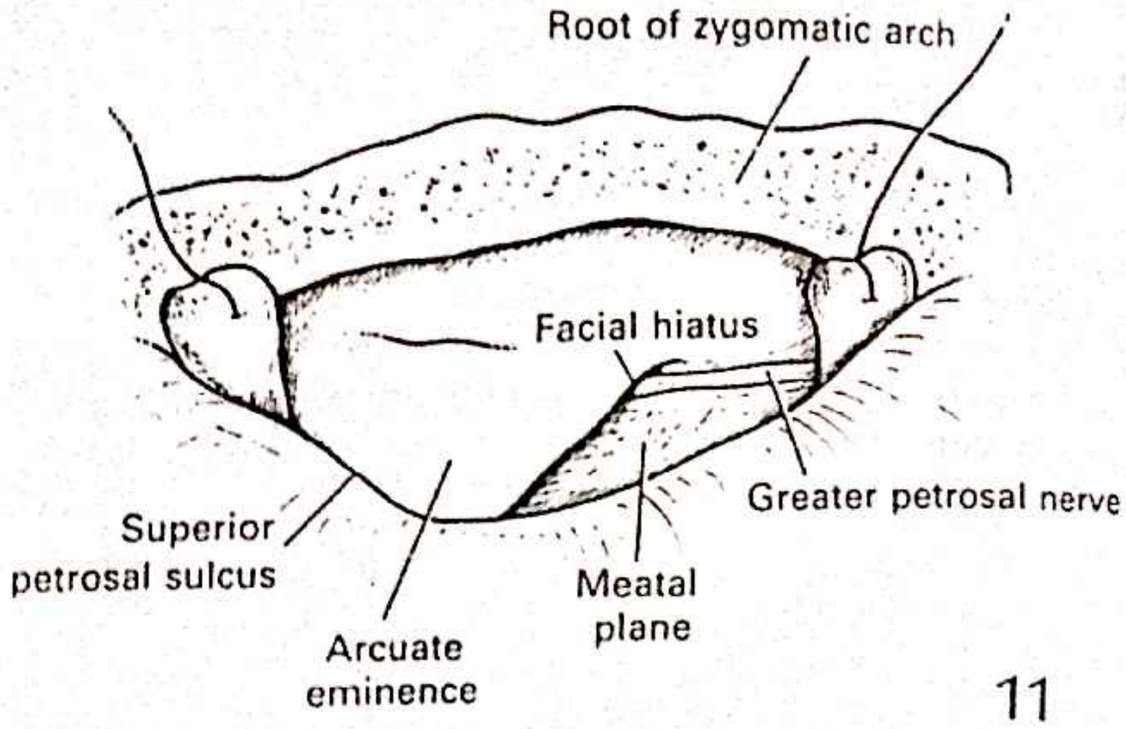
The dura is elevated from the floor of the middle cranial fossa in a posterior–anterior direction, using a modified dental raspatory. The petrosquamous attachment of the dura as well as the veins found along the base of the middle cranial fossa (particularly the superior petrosal vein) are coagulated bipolarly.



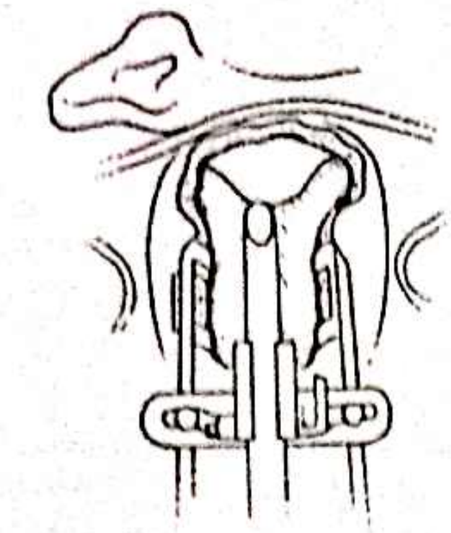
10

11

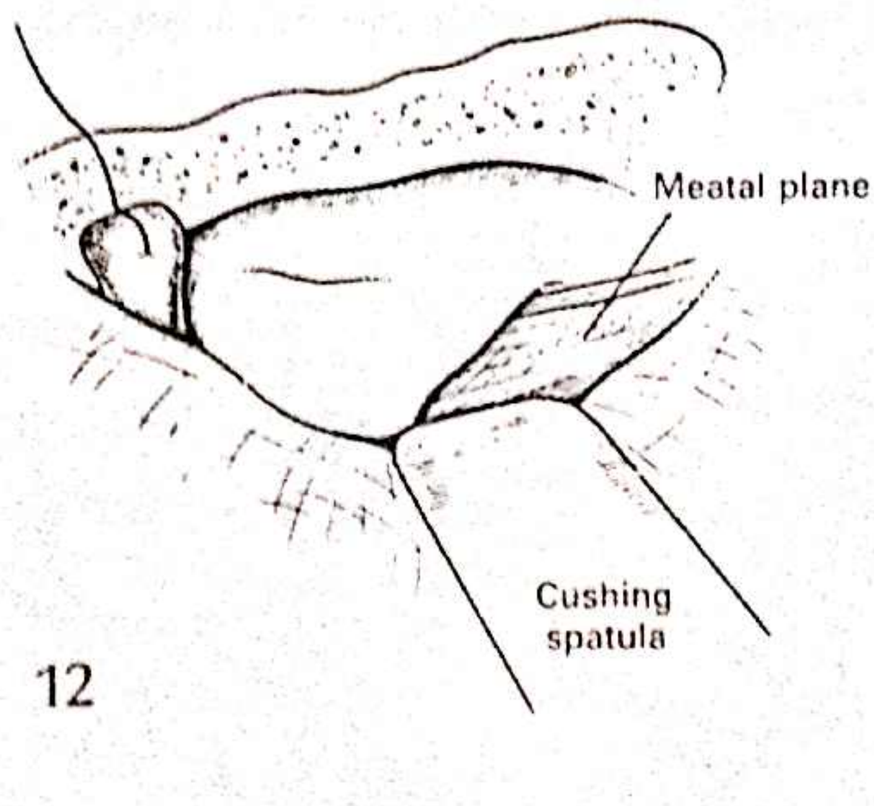
Elevation of the dura from the base of the middle cranial fossa is carried out posteriorly to the superior petrosal sulcus. From here it is continued anteriorly over the arcuate eminence and up to the bone over the internal auditory canal. We call this area the meatal plane. Elevation of the dura is stopped after exposure of the facial hiatus. In a well pneumatized bone the greater petrosal nerve may run deep in the bone for a long stretch. In this case, elevation of the dura is discontinued after exposing the meatal plane for 2cm anteriorly to the arcuate eminence. This avoids unnecessary bleeding from the veins in close proximity to the carotid canal and temporosphenoid suture. Exposure of the middle meningeal artery is not necessary.



11



Mechanical
dura retractor



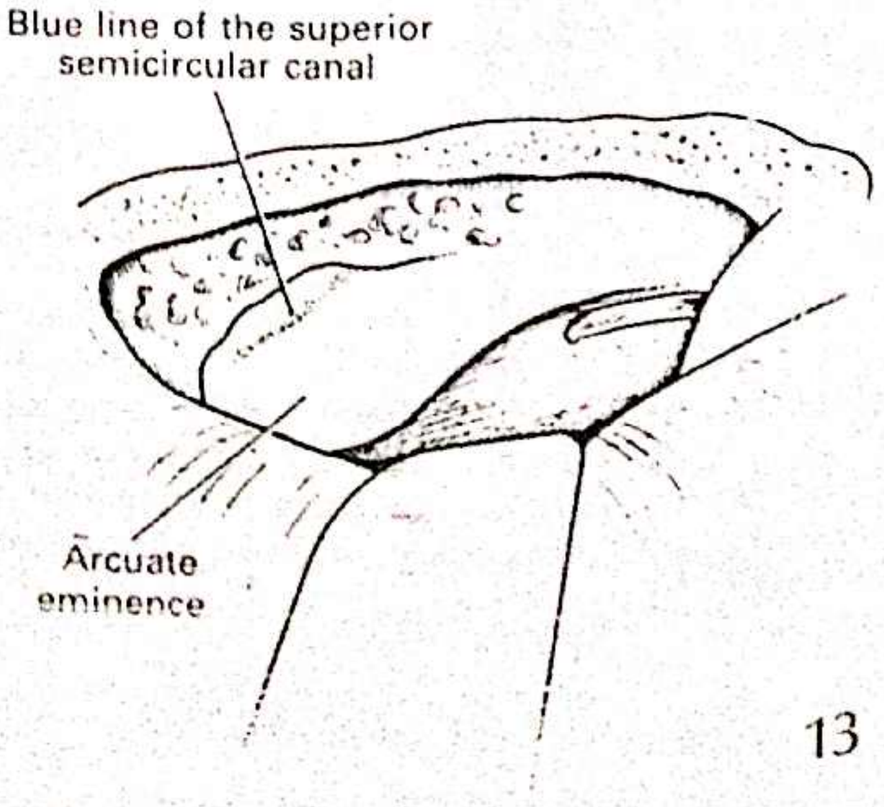
12

12

A mechanical dura retractor is fixed to the edges of the craniotomy and the Cushing spatula is introduced. The tip of the spatula rests over the petrosal sulcus, medial to the edge of the meatal plane and just anterior to the arcuate eminence. The operation is now continued using the magnification afforded by the operating microscope.

13

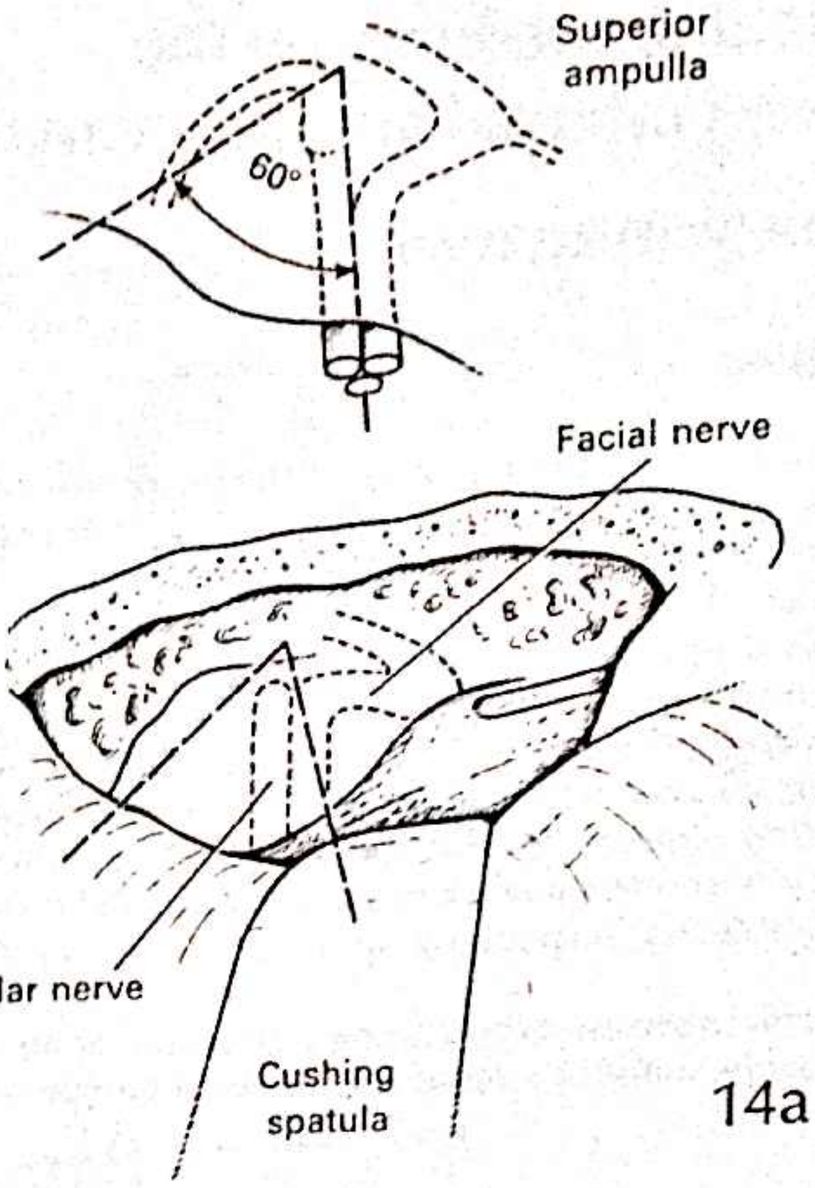
Using suction-irrigation and a diamond burr, the bone over the arcuate eminence is removed. The compact labyrinthine bone is easily identifed from the surrounding pneumatic bone. The contours of the bony superior semicircular canal are delineated. The 'blue line' of the membranous canal is then found by using a technique similar to that for fenestration of the lateral semicircular canal.



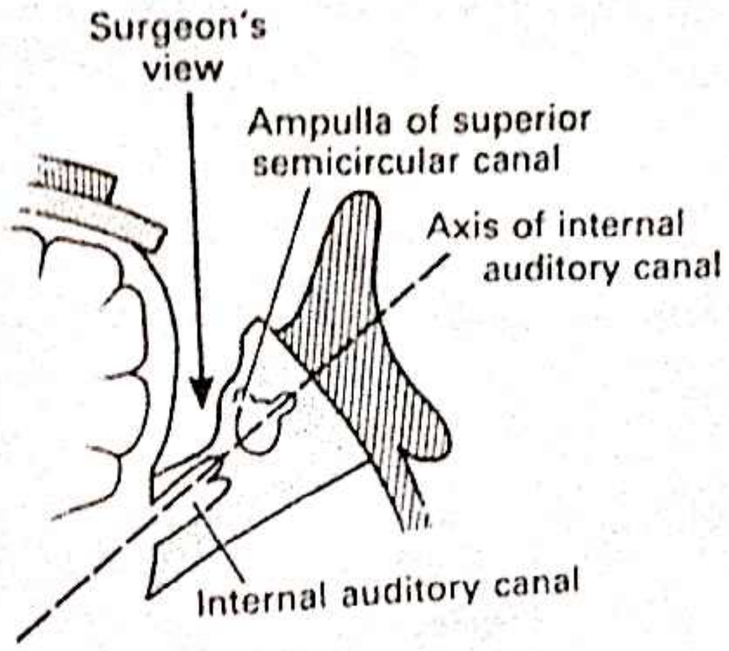
13

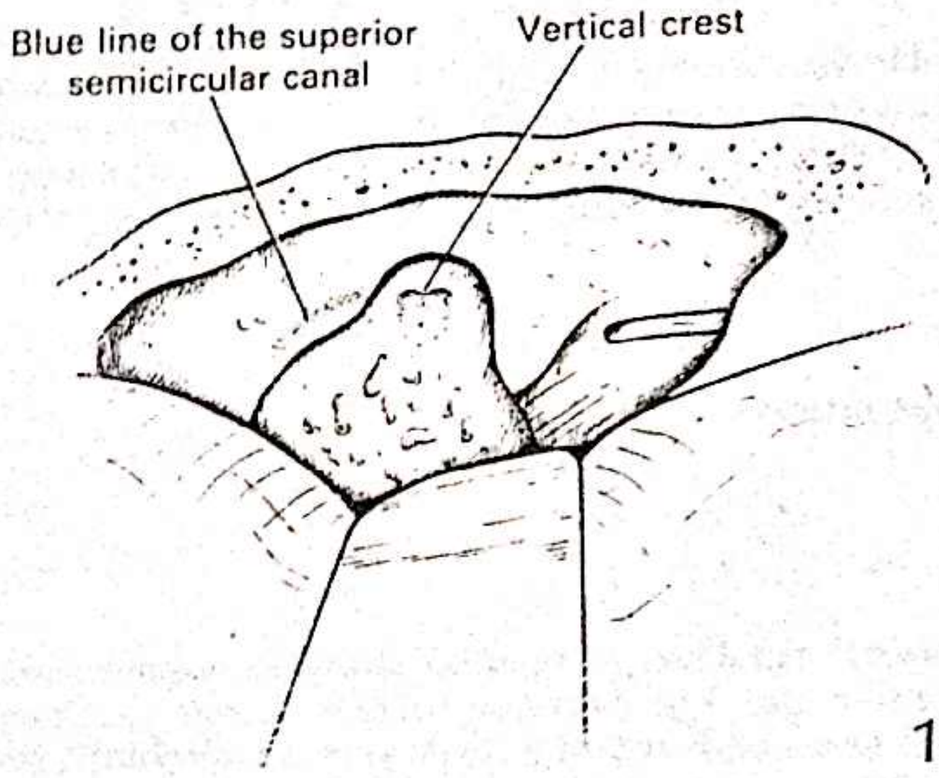
14a, b & c

The internal auditory canal is identifed by removing the bone, in a sector of 60°, anterior to the superior semicircular canal (*a*). This exposes the blue area of the meatal fundus (*b*) without risk to the facial nerve and the basal turn of the cochlea. Quite often, removal of the bone has to be carried out laterally, very close to the ampulla and the superior semicircular canal, because of the overhang produced by the angulation between the axes of the temporal bone and that of the surgeon's view (*c*). Careful exposure of the meatal fundus, including the vertical crest (Bill's bar), is essential for the identification of the facial and superior vestibular nerves, particularly when these lie on the floor of a large internal auditory meatus.

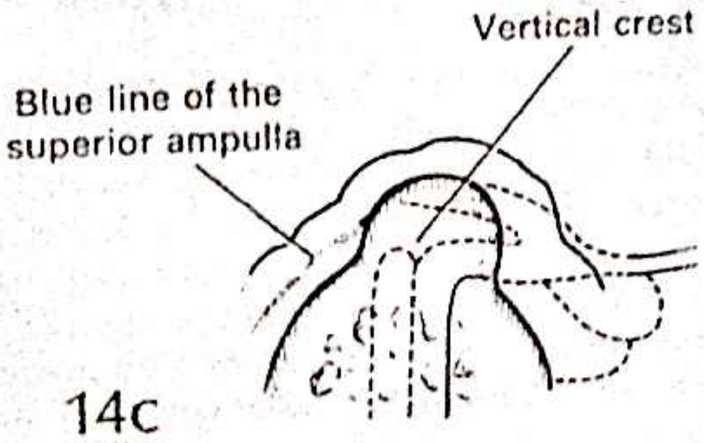


14a

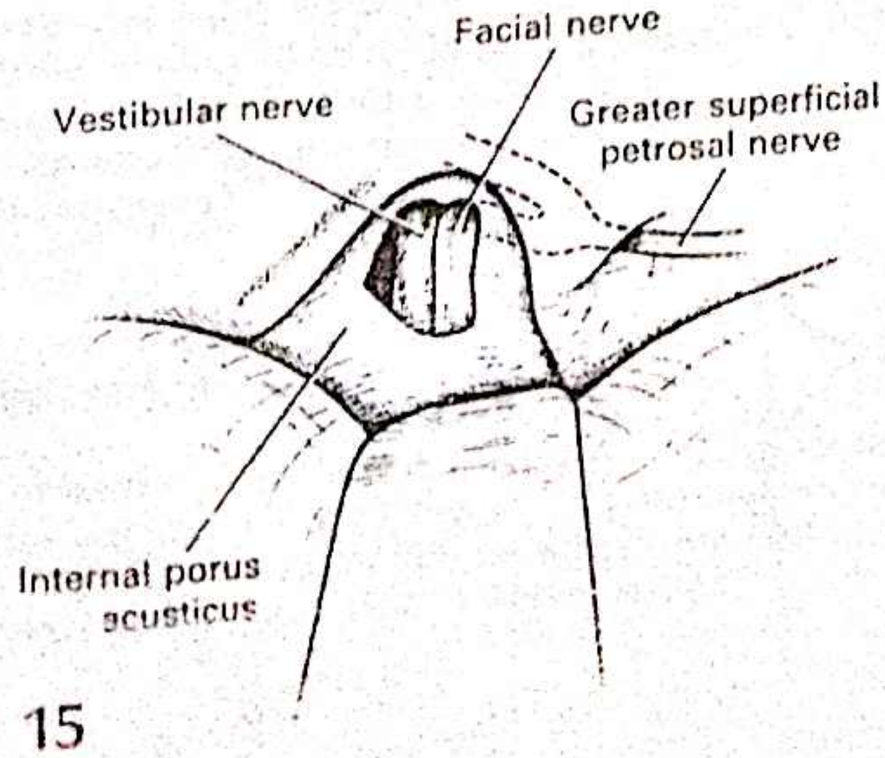




14b



14c



15

15

The meatal dural sac is exposed by removing the bone over it with a diamond burr and suction-irrigation. Usually the vestibular and facial nerves become visible through the thin dura.

Surgical procedures on the exposed internal auditory canal

VESTIBULAR NEURECTOMY

Indications

Excision of the meatal segment of the vestibular nerve is indicated in disabling vertigo of peripheral origin resistant to medical treatment (Menière's disease; acute or progressive loss of vestibular or cochleovestibular function following viral or vascular disease; dizziness resulting from postoperative labyrinthitis or labyrinthosis).

The patient should be informed that surgery will be followed by complete unilateral loss of vestibular function. Compensation for this loss usually takes 4–8 weeks. Motivation to resume work has been found to be the most important factor in speeding up the process of compensation.

Bilateral nerve sections can be performed at an interval of 6 months without special problems of compensation.

Contraindications

Vestibular neurectomy is contraindicated in patients with infections of the middle ear, chronic otitis media, infected radical cavities, associated central vestibular dysfunction, and psychological problems (in patients over the age of 65 years).

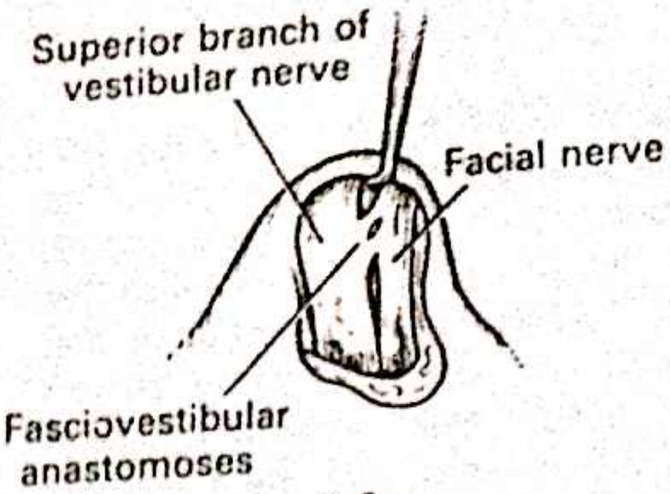
The operation

16

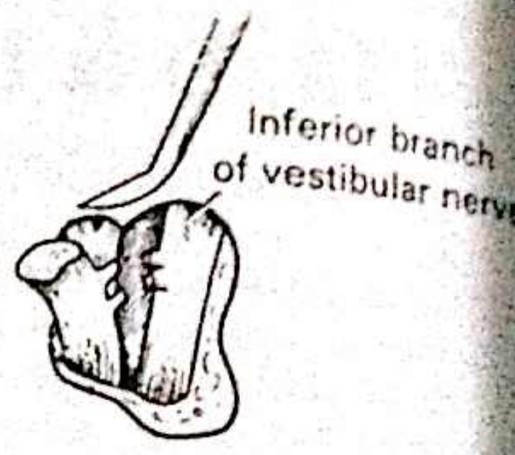
The meatal dural sac is opened along its superior and posterior edge. The superior branch of the vestibular nerve is separated from the facial with a micro-hook (a). The superior branch of the vestibular nerve and the faciovestibular anastomosis are cut with a neurotomy knife (*b*). The inferior vestibular branch is exposed by pulling out the superior branch with a suction tube. The inferior vestibular branch is identified next to the cochlear nerve and cut with the neurotomy knife. The arterial supply of the vestibular ganglion is coagulated bipolarly (c). The meatal segment of the vestibular nerve, including the vestibular ganglion, is excised with a pair of neurotomy scissors (*d*). Intraneural bleeding vessels are coagulated bipolarly (*e*). The exposed internal auditory canal is covered with a free muscle graft in order to avoid postoperative cerebrospinal fluid leak (*f*).

Complications

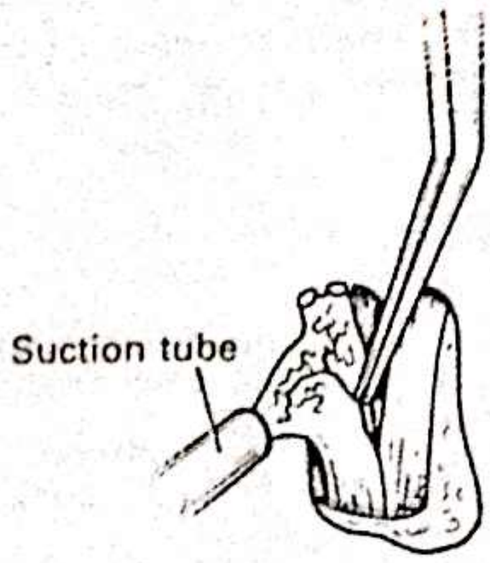
Delayed transitory facial paresis occurs in 3 per cent of cases; transitory rhinoliquorrhoea in 6 per cent of cases; total deafness in 2 per cent of cases.



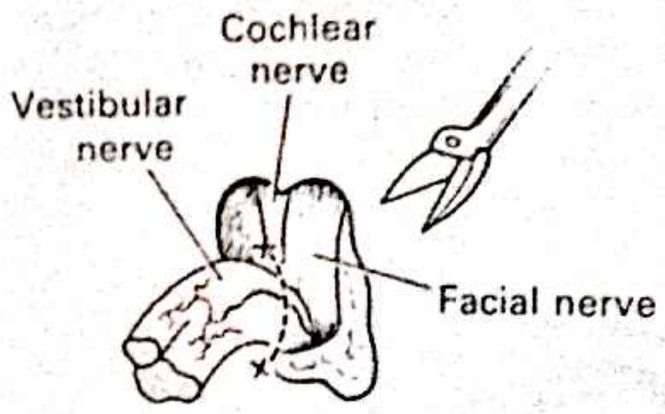
16a



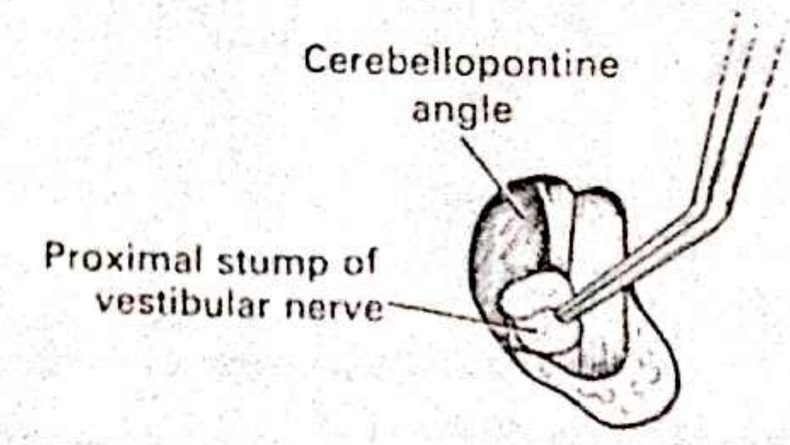
16b



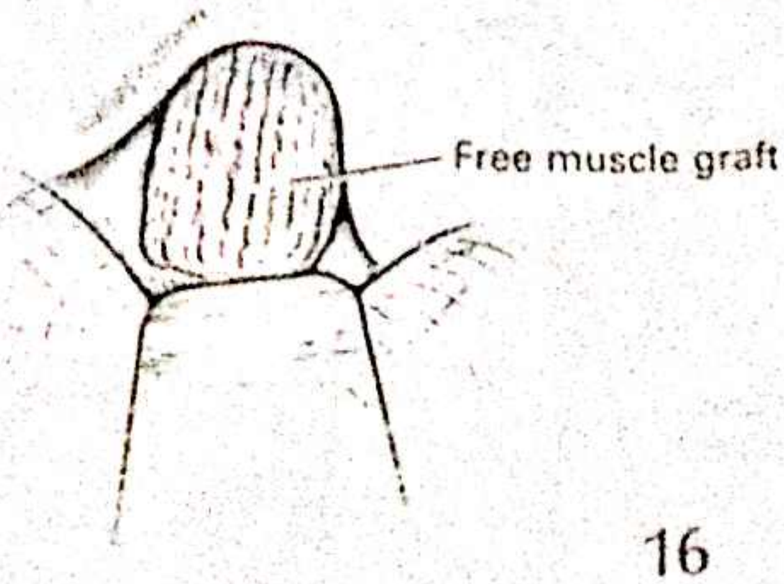
16c



16d



16e



16

Surgical procedures on the exposed internal auditory canal

VESTIBULAR NEURECTOMY

Indications

Excision of the meatal segment of the vestibular nerve is indicated in disabling vertigo of peripheral origin resistant to medical treatment (Menière's disease; acute or progressive loss of vestibular or cochleovestibular function following viral or vascular disease; dizziness resulting from postoperative labyrinthitis or labyrinthosis).

The patient should be informed that surgery will be followed by complete unilateral loss of vestibular function. Compensation for this loss usually takes 4–8 weeks. Motivation to resume work has been found to be the most important factor in speeding up the process of compensation.

Bilateral nerve sections can be performed at an interval of 6 months without special problems of compensation.

Contraindications

Vestibular neurectomy is contraindicated in patients with infections of the middle ear, chronic otitis media, infected radical cavities, associated central vestibular dysfunction, and psychological problems (in patients over the age of 65 years).

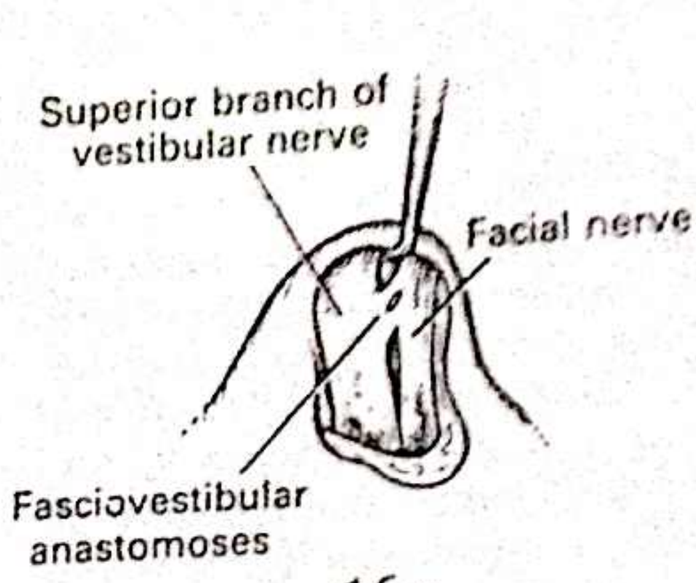
The operation

16

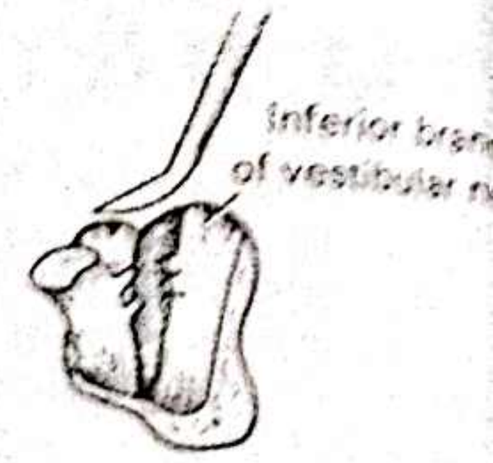
The meatal dural sac is opened along its superior and posterior edge. The superior branch of the vestibular nerve is separated from the facial with a micro-hook (*a*). The superior branch of the vestibular nerve and the faciovestibular anastomosis are cut with a neurotomy knife (*b*). The inferior vestibular branch is exposed by pulling out the superior branch with a suction tube. The inferior vestibular branch is identifed next to the cochlear nerve and cut with the neurotomy knife. The arterial supply of the vestibular ganglion is coagulated bipolarly (*c*). The meatal segment of the vestibular nerve, including the vestibular ganglion, is excised with a pair of neurotomy scissors (*d*). Intraneural bleeding vessels are coagulated bipolarly (*e*). The exposed internal auditory canal is covered with a free muscle graft in order to avoid postoperative cerebrospinal fluid leak (*f*).

Complications

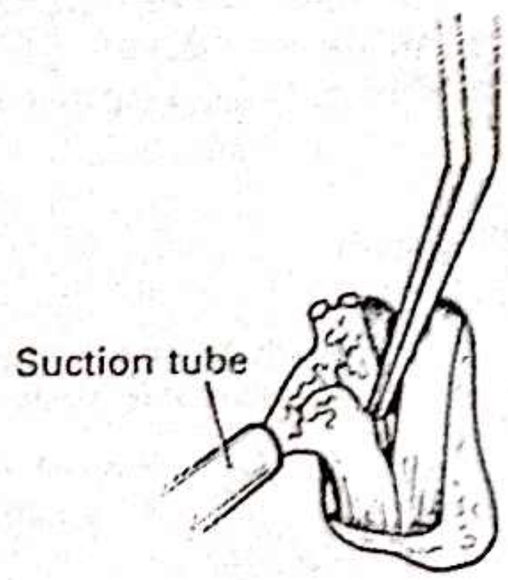
Delayed transitory facial paresis occurs in 3 per cent of cases; transitory rhinoliquorrhoea in 6 per cent of cases; total deafness in 2 per cent of cases.



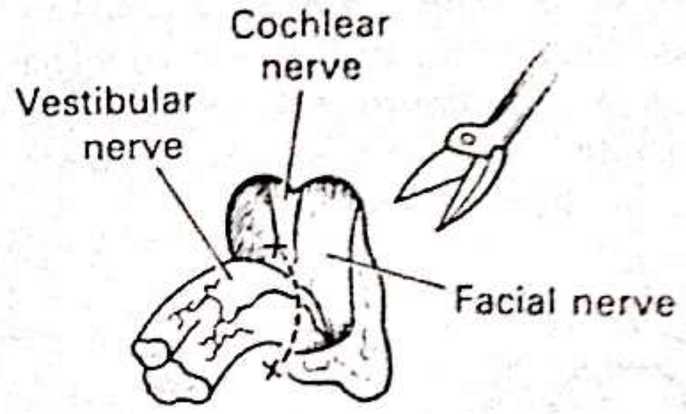
16a



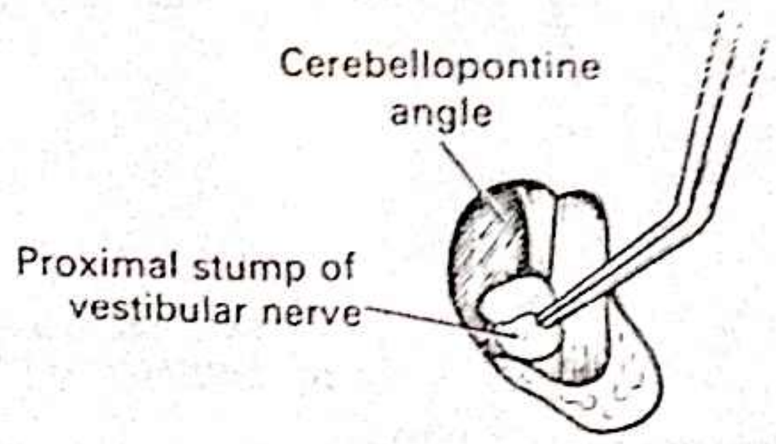
16b



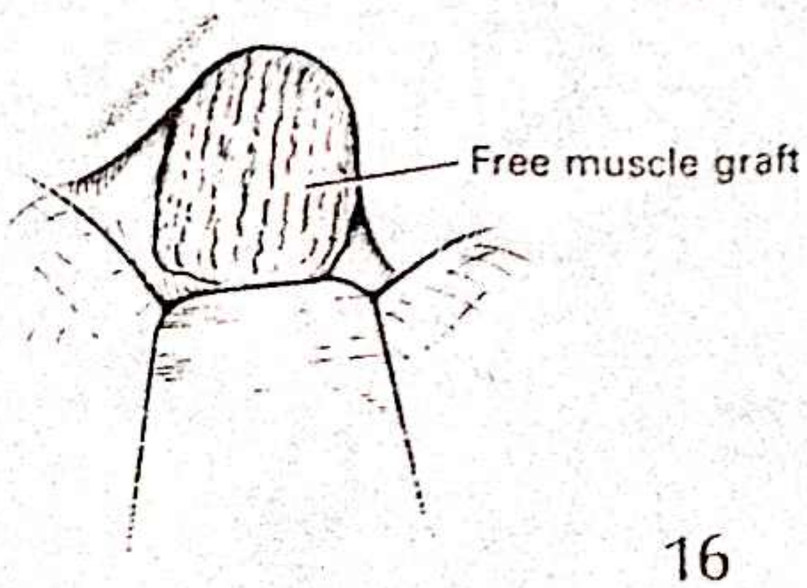
16c



16d



16e



16

SELECTIVE SECTION OF THE COCHLEAR NERVE

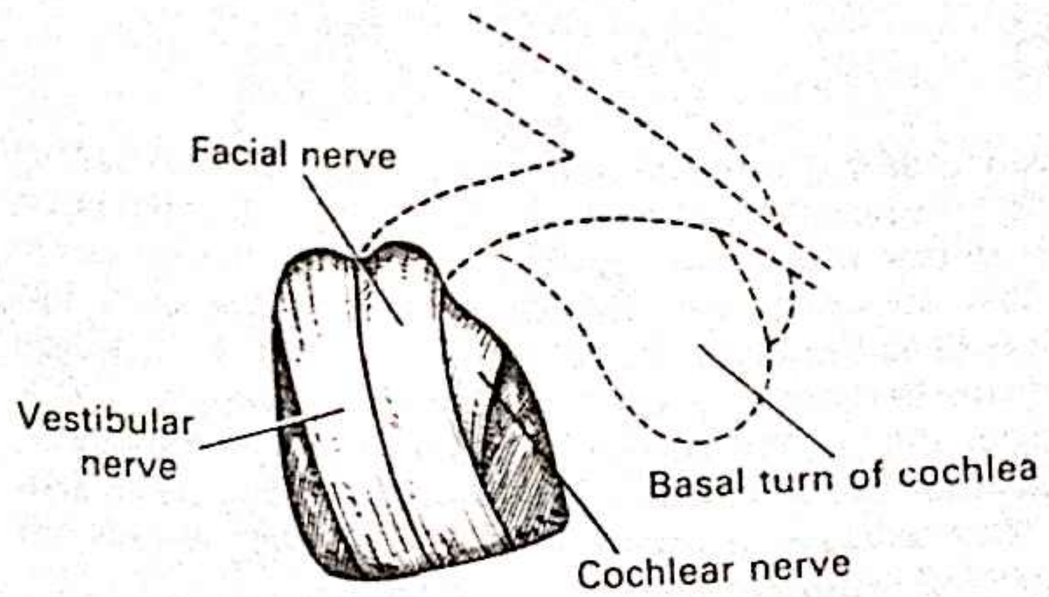
Selective section of the cochlear nerve is indicated for disabling tinnitus following a total loss of hearing with preserved vestibular function.

Contraindications are as for vestibular neurectomy.

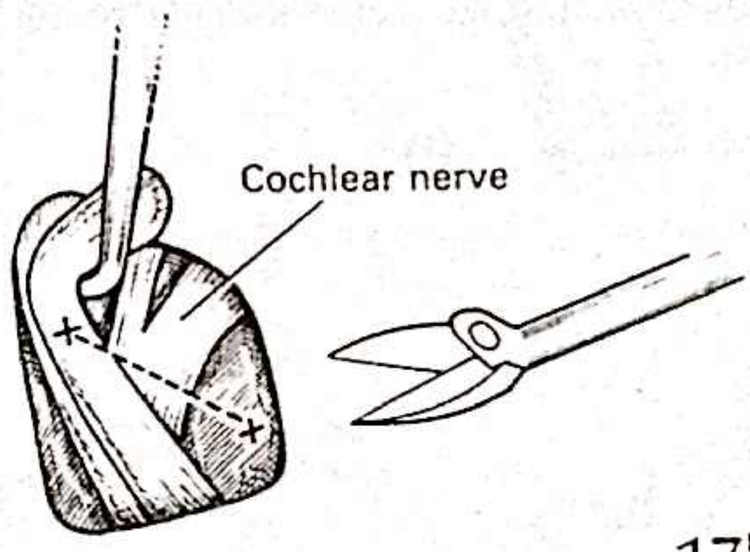
The operation

17

The anterior portion of the internal auditory meatus is exposed as far as possible behind the basal turn of the cochlea. The cochlear nerve is identified at the entrance to the modiolus (*a*). After gentle retraction of the facial nerve the cochlear nerve is cut with neurectomy scissors (*b*). Bleeding vessels are coagulated bipolarly.



17a



17b

Complications

The complications are similar to those encountered after vestibular neurectomy.

VIIIth NERVE SECTION (COCHLEOVESTIBULAR NEURECTOMY)

Since severely impaired cochlear function is often followed by a corresponding loss of vestibular function, total VIIIth nerve section is more commonly performed than selective section of the cochlear nerve. Usually for this last operation the translabyrinthine approach is the one of choice. In the presence of a dry radical cavity or other contraindications for a translabyrinthine operation, the middle cranial fossa approach is the one of choice.

Indications

VIIIth nerve section is usually indicated for severe tinnitus after fenestration surgery or radical operations followed by loss of cochleovestibular function.

The contraindications are the same as for section of the vestibular nerve.

The operation

The procedures used for vestibular neurectomy and selective section of the cochlear nerve can be combined in order to perform a complete section of the cochlear and vestibular nerve fibres (VIIIth nerve section).

Complications

The complications are the same as those for section of the vestibular nerve.

REMOVAL OF INTRAMEATAL TUMOURS

Indications

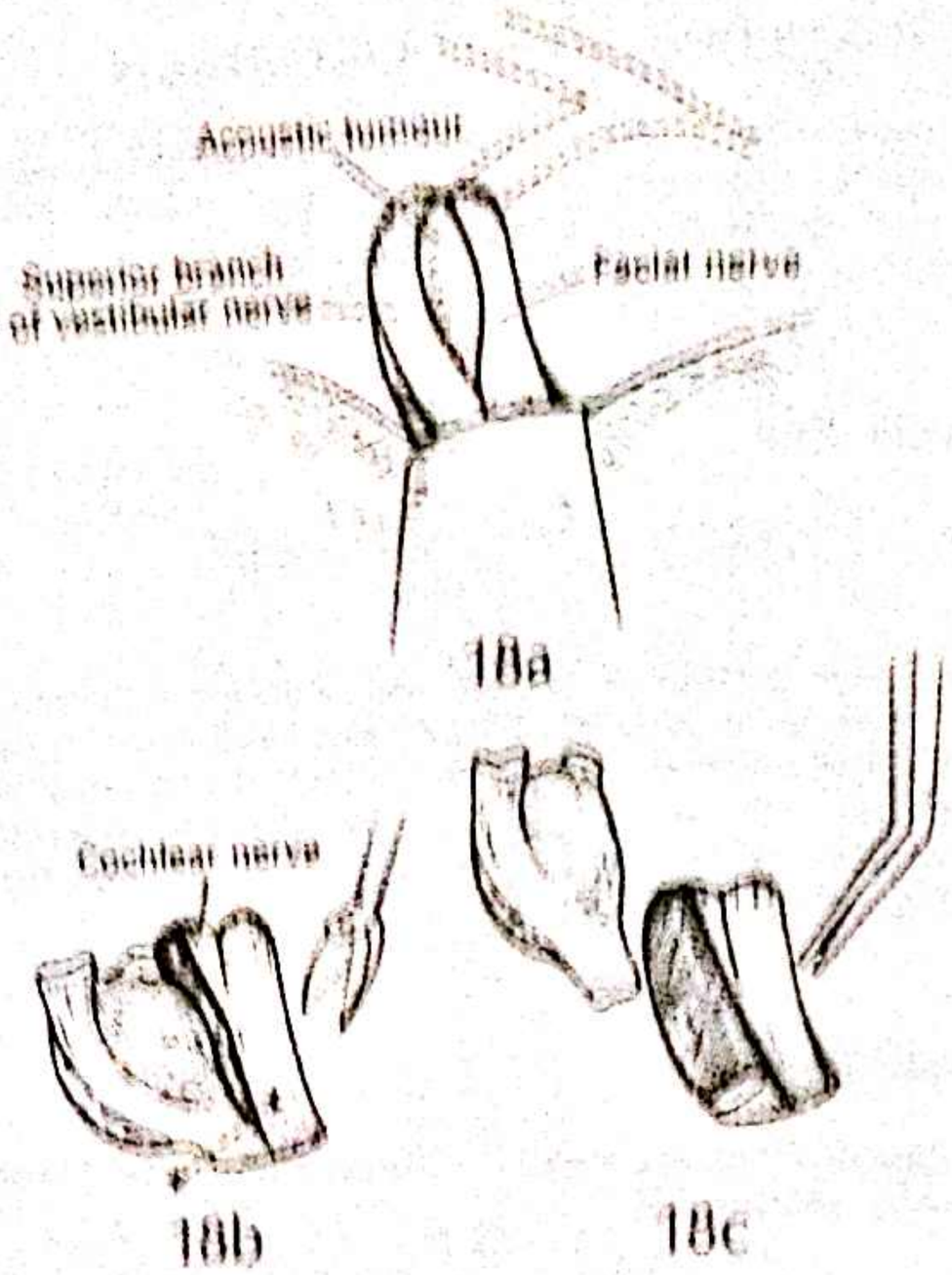
Acoustic neuromas or any other intrameatal tumour of less than 8 mm in diameter can be removed by this approach.

However, tumour extending through the porus into the cerebellopontine angle is a contraindication in view of the limited access in the intracranial area. For tumours protruding into the cerebellopontine angle the translabyrinthine approach or one of the neurosurgical approaches is preferred.

The operation

18

Exposure of the internal auditory canal is carried out as medially as possible. The tumour is usually found between the superior and inferior divisions of the vestibular nerve (a). The superior and inferior vestibular branches are sectioned as distally as possible and the tumour is pulled out from the canal, preserving the blood supply of the cochlear nerve. The vestibular nerve is cut proximally to the tumour at the entrance of the internal auditory canal (b). After removal of the tumour the bleeding vessels are coagulated bipolarly (c).



18a 18b 18c

Complications

The most important complication is loss of hearing (25 per cent of cases).

REMOVAL OF A FACIAL NERVE NEUROMA

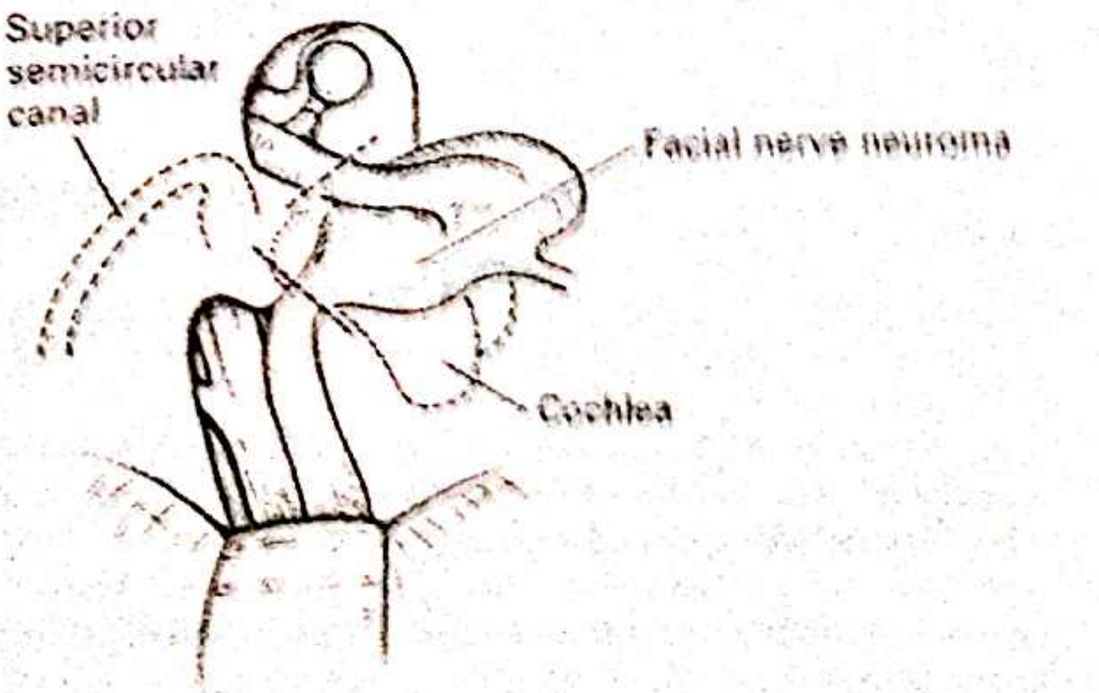
Facial nerve neuromas localized in the labyrinthine and meatal segments of the facial nerve present with progressive paralysis of the face and with conductive deafness.

Poor general condition of the patient is a contraindication to surgery.

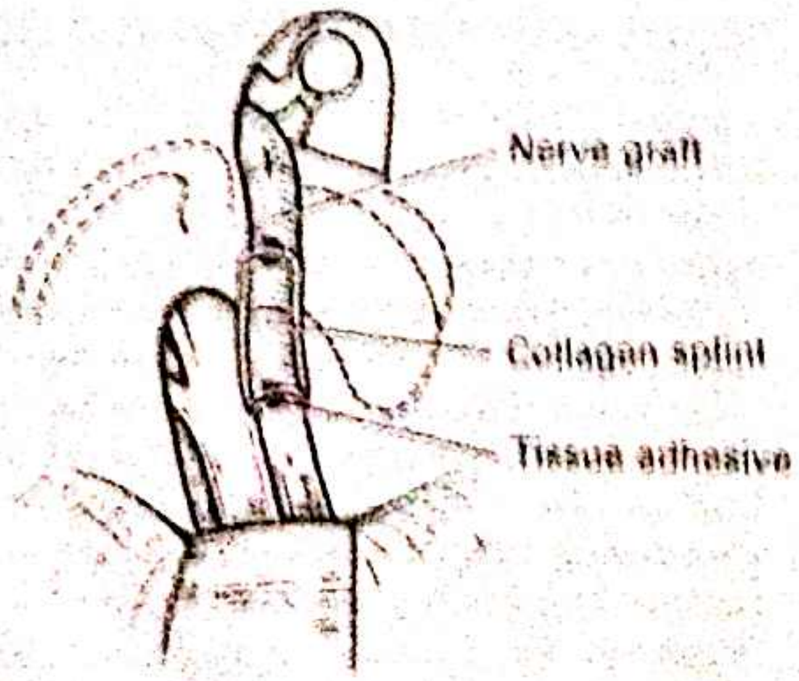
The operation

19

In the case of a facial nerve neuroma originating in the labyrinthine segment of the nerve the tympanic portion of the nerve should also be exposed through an opening in the tegmen tympani (a). Any intracanalal extension of the tumour is handled as indicated in *Illustration 18*. Usually, however, the growth of a facial nerve neuroma stops a few millimetres before the nerve's entrance into the Fallopian canal. The neuroma is excised with neurectomy scissors. After re-routing of the Fallopian canal along the superior ampulla, the nerve stumps are approximated end to end or a nerve graft is inserted. To secure the anastomsis, 'collagen' splints and tissue adhesive (Histoacryl) have been found very useful (b). More distally, perineural sutures of 10/0 perlon (nylon) are preferred.



19a



19b

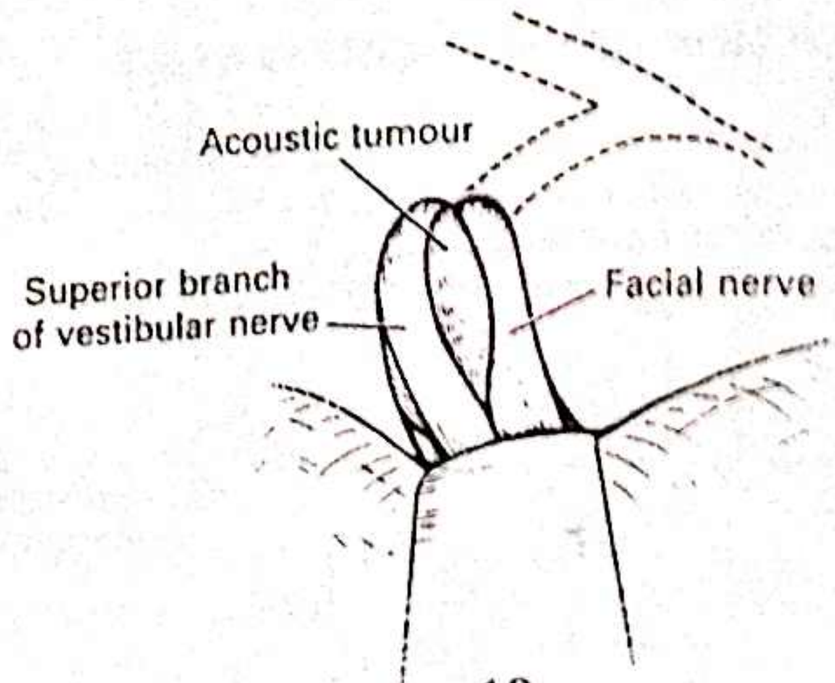
Complications

A transitory cerebrospinal fluid leak may occur if the tumour extends into the internal auditory canal.

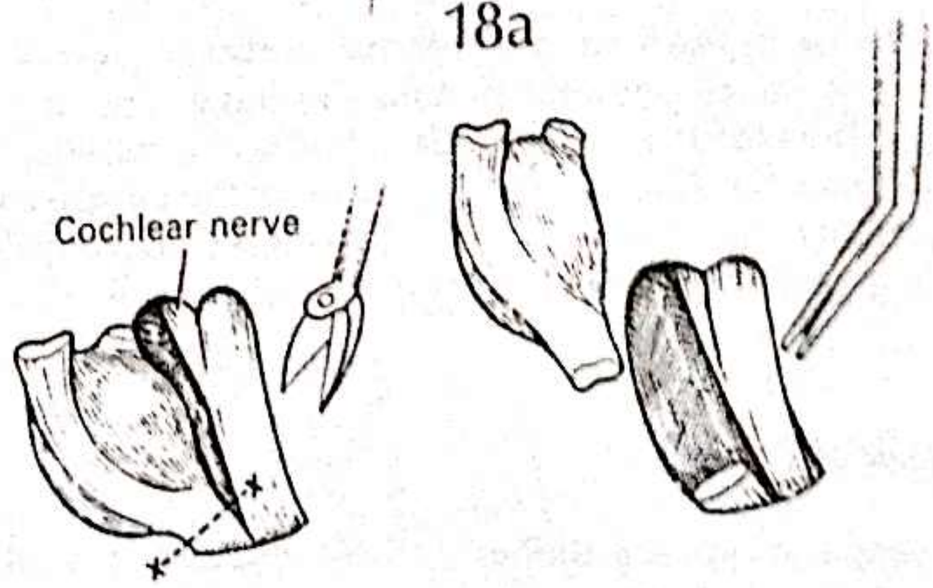
The operation

18

Exposure of the internal auditory canal is carried out as medially as possible. The tumour is usually found between the superior and inferior divisions of the vestibular nerve (a). The superior and inferior vestibular branches are sectioned as distally as possible and the tumour is pulled out from the canal, preserving the blood supply of the cochlear nerve. The vestibular nerve is cut proximally to the tumour at the entrance of the internal auditory canal (*b*). After removal of the tumour the bleeding vessels are coagulated bipolarly (*c*).



18a



18b

18c

Complications

The most important complication is loss of hearing (25 per cent of cases).

REMOVAL OF A FACIAL NERVE NEUROMA

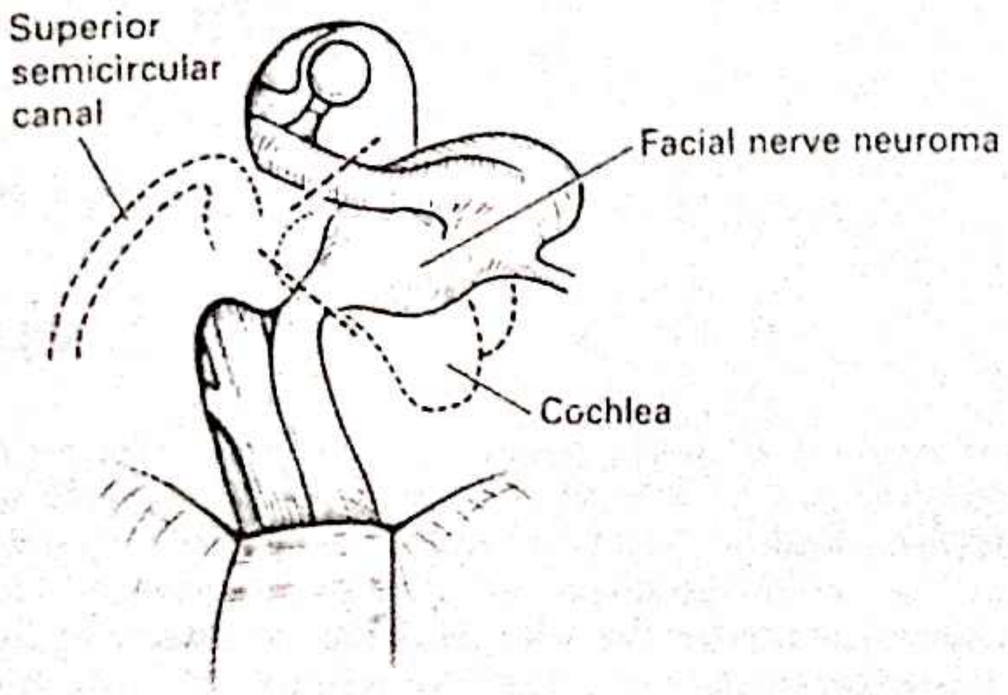
Facial nerve neuromas localized in the labyrinthine and meatal segments of the facial nerve present with progressive paralysis of the face and with conductive deafness.

Poor general condition of the patient is a contraindication to surgery.

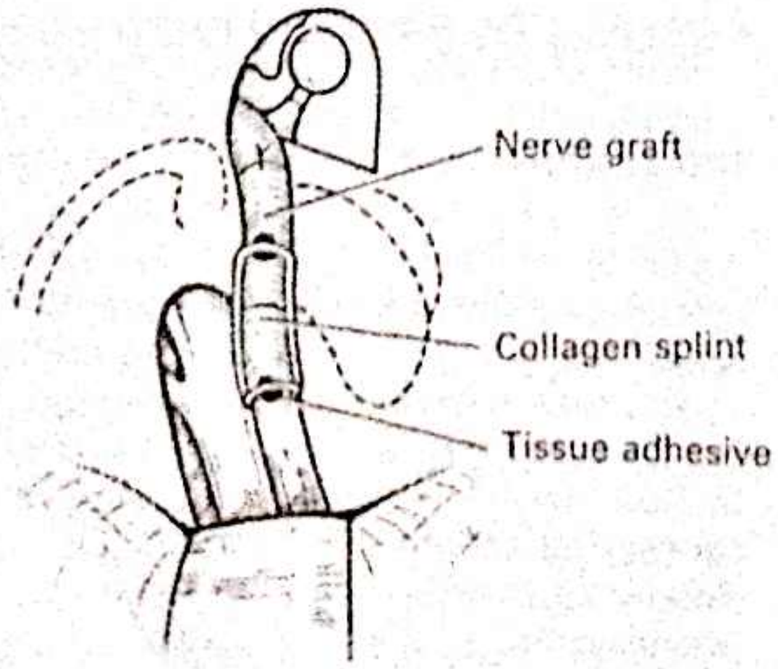
The operation

19

In the case of a facial nerve neuroma originating in the labyrinthine segment of the nerve the tympanic portion of the nerve should also be exposed through an opening in the tegmen tympani (a). Any intrameatal extension of the tumour is handled as indicated in *Illustration 18*. Usually, however, the growth of a facial nerve neuroma stops a few millimetres before the nerve's entrance into the Fallopian canal. The neuroma is excised with neurectomy scissors. After re-routing of the Fallopian canal along the superior ampulla, the nerve stumps are approximated end to end or a nerve graft is inserted. To secure the anastomsis, 'collagen' splints and tissue adhesive (Histoacryl) have been found very useful (*b*). More distally, perineural sutures of 10/0 perlon (nylon) are preferred.



19a



19b

Complications

A transitory cerebrospinal fluid leak may occur if the tumour extends into the internal auditory canal.

REMOVAL OF PRIMARY CHOLESTEATOMA OF THE ANTERIOR EPITYMPANIC SPACE

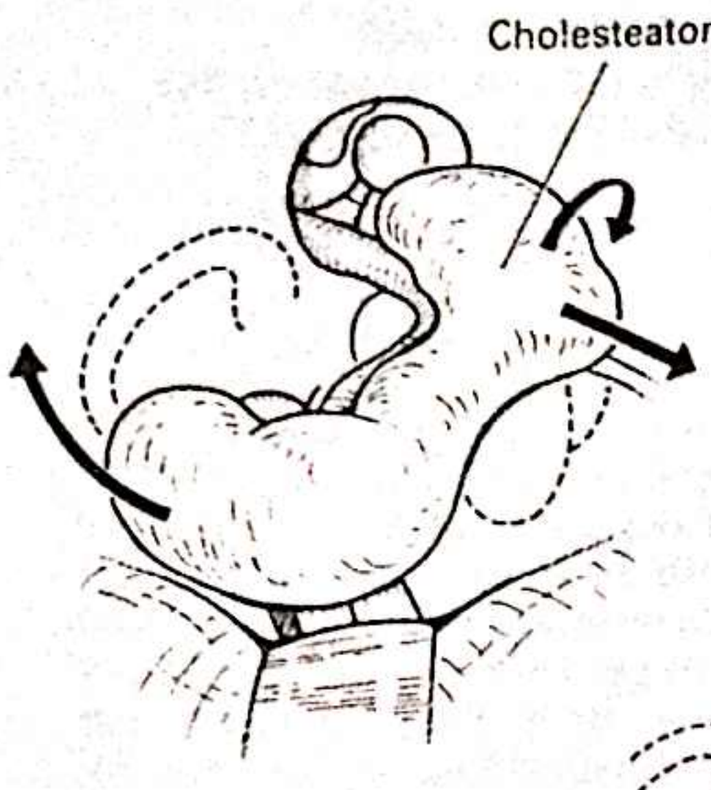
These lesions usually present with progressive facial palsy, with or without associated hearing loss. X-ray shows a sharply defined bony defect over the internal auditory canal.

20

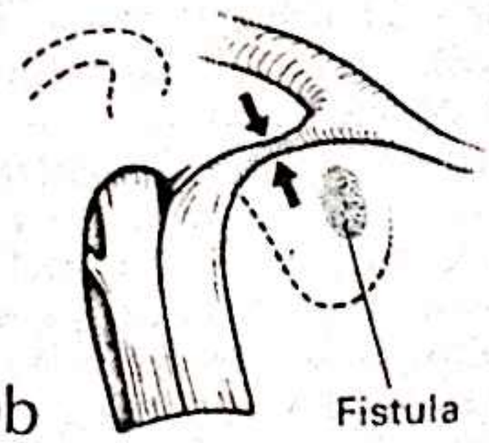
This type of cholesteatoma is very dangerous and develops along the labyrinthine segment of the facial nerve in three main directions: (1) over the meatal plane, posterior to the superior semicircular canal, into the mastoid region; (2) along the greater petrosal nerve; and (3) down into the hypotympanum and the carotid canal (a). Such a cholesteatoma must be removed very gently because there may be extensive labyrinthine fistulae (mainly of the basal turn and superior ampulla) and extensive compression of the facial nerve z(*b*).

Complications

The commonest complication is loss of hearing due to exposure of previously asymptomatic extensive labyrinthine fistulae. It is therefore essential to inform the patient of this risk before surgery.



20a



20b

REPAIR OF TRAUMATIC FACIAL NERVE LESIONS AFTER LONGITUDINAL FRACTURES OF THE PYRAMID

Exploratory surgery of the facial nerve is indicated if degeneration of the motor fibres reaches more than 90 per cent within 6 days after the onset of the palsy, or if regeneration is not taking a normal course after 6 months.

Poor general condition of the patient is a contraindication to such surgery.

21

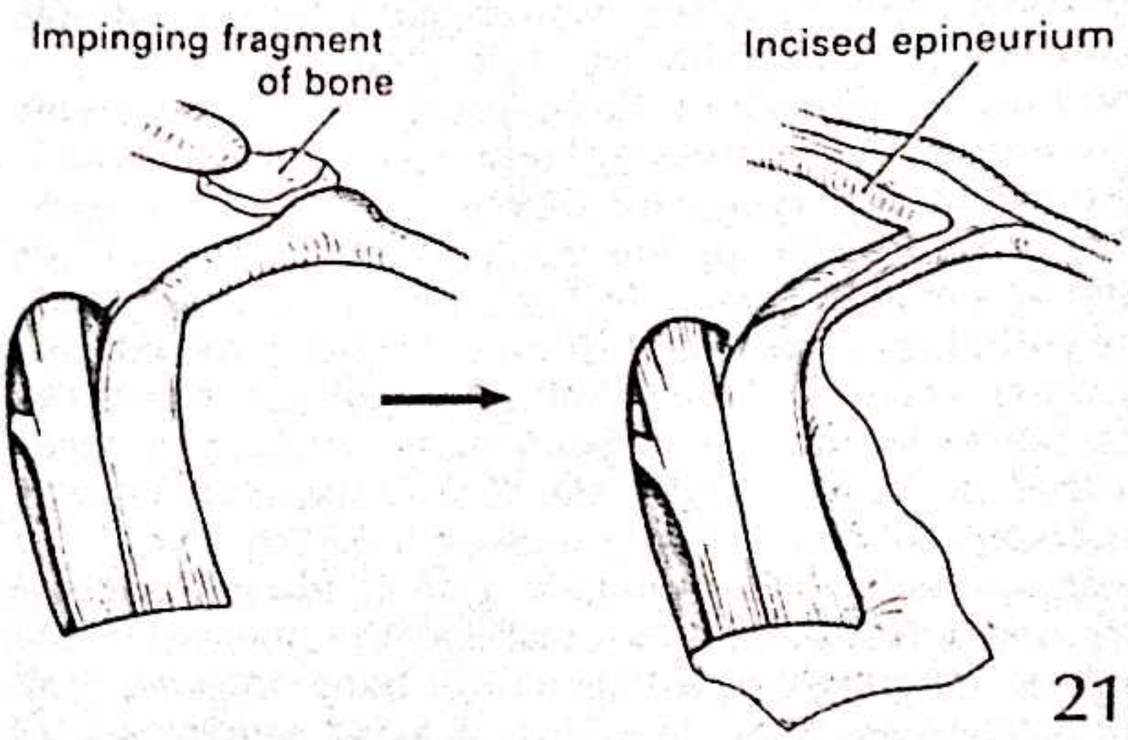
Longitudinal fractures of the pyramid may give rise to the following types of facial nerve injuries:

1. Impinging fragment of bone into the Fallopian canal (a).
2. Complete section of the facial nerve, mostly in the infrageniculate region (*b*).
3. Intraneural haematoma with traction injury of the greater superficial petrosal nerve (c).

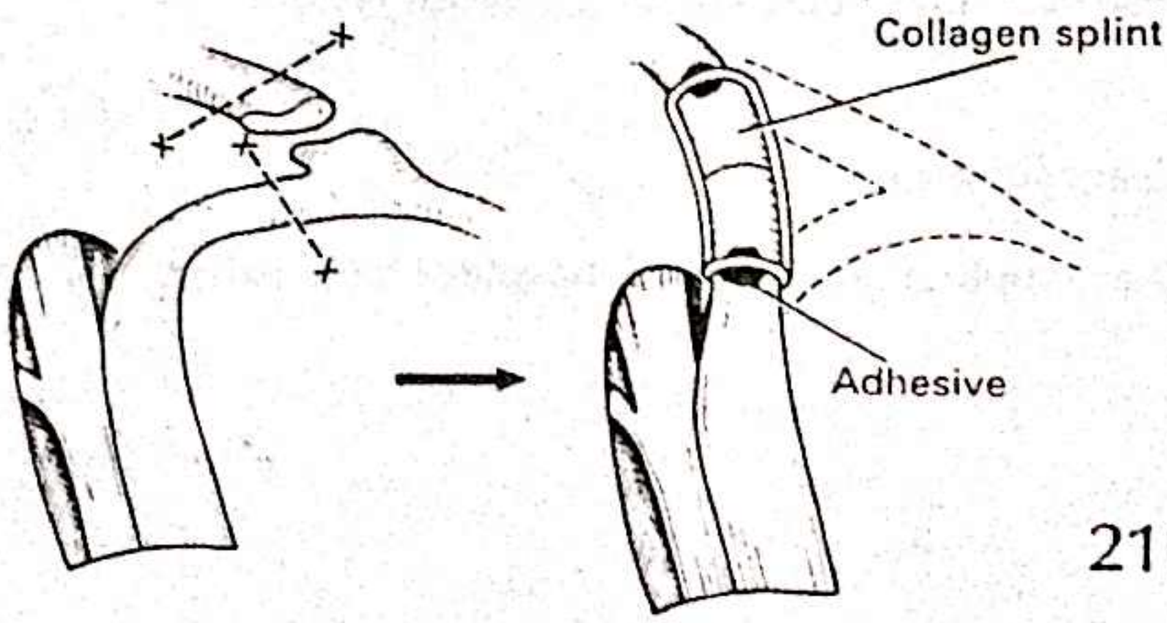
Surgical repair of these lesions involves removing the impinging fragment of bone and incising the epineurium (a); excision of the geniculate ganglion with re-routing and end to end anastomosis of the facial nerve stumps (*b*); and incision of the epineurium for evacuation of an intraneural haematoma and clipping of the greater petrosal nerve (c). Clipping of the greater petrosal nerve is necessary in order to avoid misdirection of regenerating motor fibres of the facial nerve.

Complications

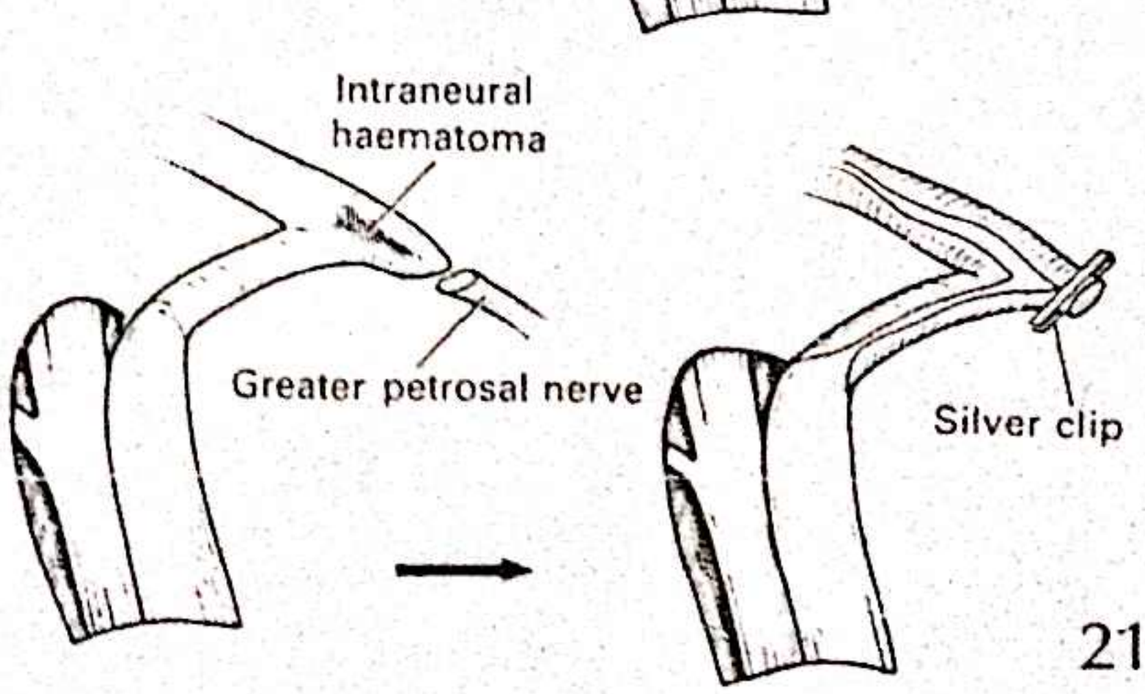
Conductive hearing loss may follow if the tegmen tympani is not reconstructed.



21a



21b



21c

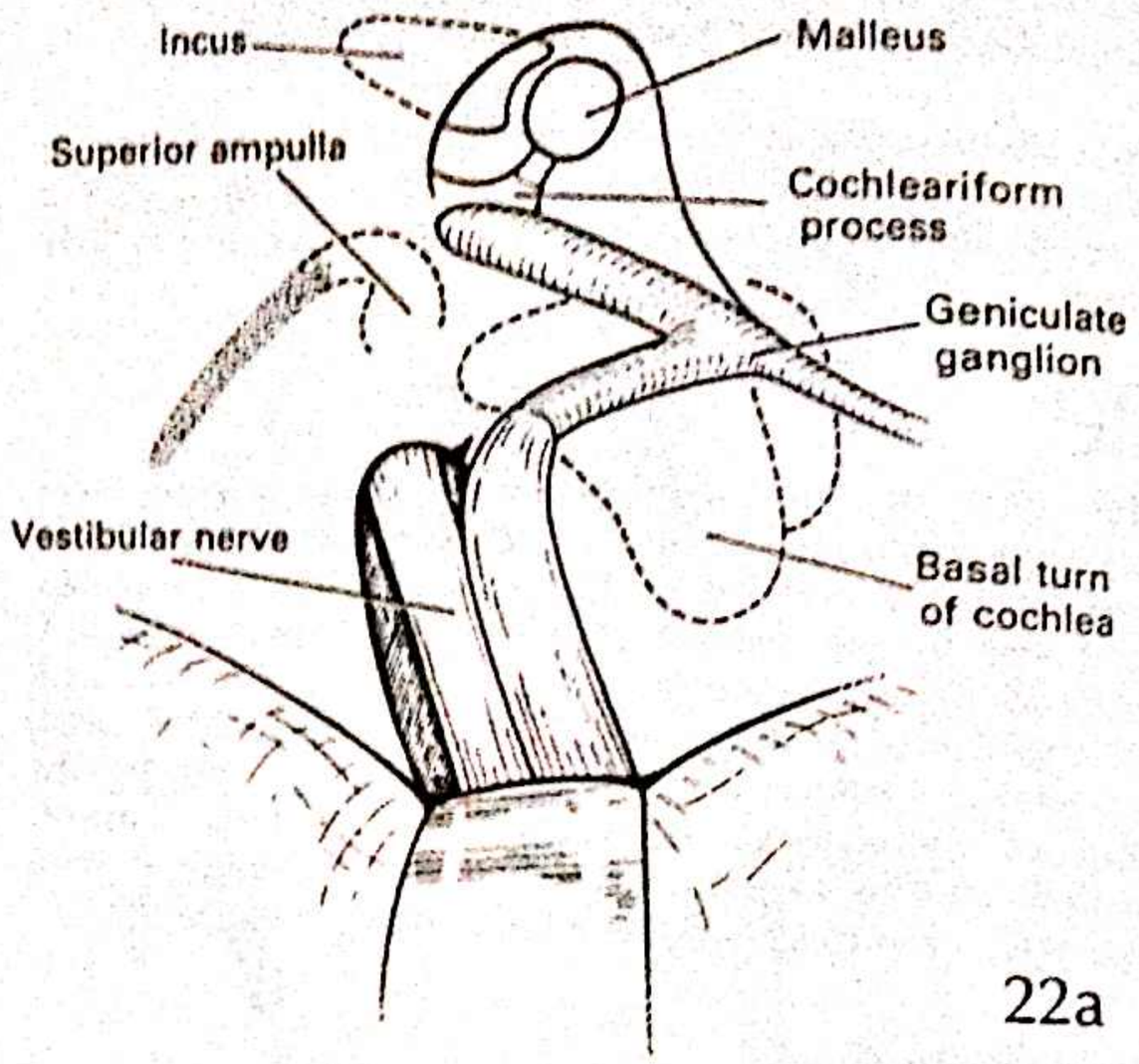
DECOMPRESSION OF THE MEATAL AND LABYRINTHINE SEGMENTS OF THE FACIAL NERVE IN IDIOPATHIC AND HERPETIC FACIAL PALSY

22

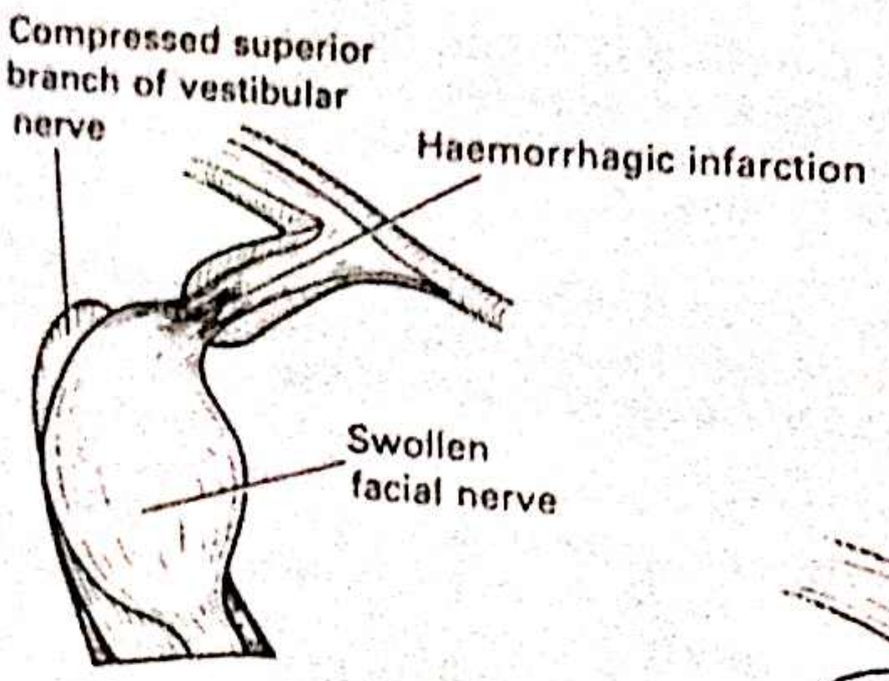
No more than 5 per cent of patients with idiopathic facial palsy require surgery. Decompression is indicated if there is more than 90 per cent degeneration (as measured by electroneuronography) within the first 12 days after onset of the palsy. In herpes zoster oticus surgery is indicated even if there is less than 90 per cent degeneration within the first 12 days of palsy, or if there are inner ear symptoms (tinnitus, sensorineural hearing loss and reduced caloric response).

Surgery is contraindicated in patients over the age of 65 years and in those who lack motivation.

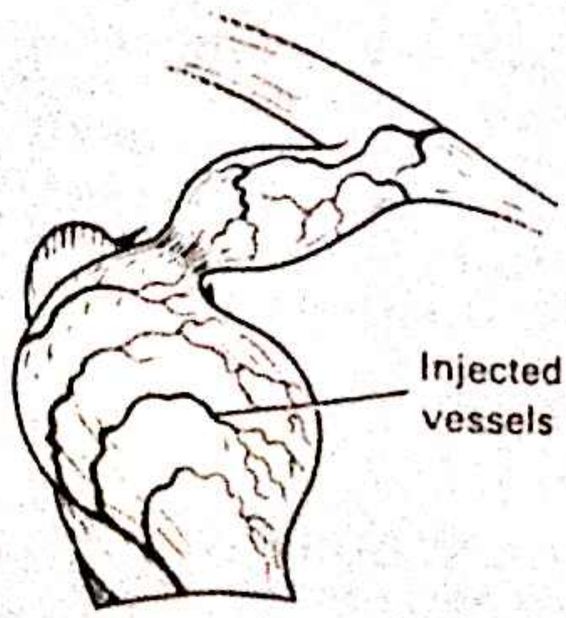
The labyrinthine and meatal segments of the facial nerve are decompressed through the middle cranial fossa by extending the approach through an opening of the tegmen into the middle ear (a). In idiopathic facial palsy, extensive swelling and haemorrhagic infarction of the facial nerve occur in the region of the meatal fundus (*b*). The superior division of the vestibular nerve may also be compressed by the swelling, thus accounting for associated vestibular symptoms. Decompression is accomplished by incision of the meatal dural sac and of the epineurium of the nerve. In cases of herpes zoster oticus, the pathology is also quite often confined to the internal auditory meatus and the proximal labyrinthine segment of the nerve. In contrast to Bell's palsy, vascular injection instead of haemorrhagic infarction is the most striking pathological change in the nerve (c). At the end of the decompression, a free muscle graft is placed over the exposed internal auditory canal and the opening in the tegmen is bridged by a fragment of bone obtained from the craniotomy flap, in order to avoid impairment of ossicular movements due to prolapsing dura.



22a



22b



22c

Complications

The complications are as for traumatic facial palsy.

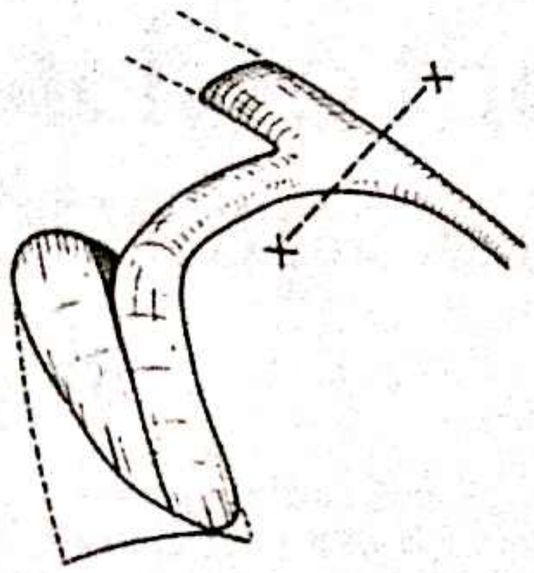
23

EXCISION OF THE GENICULATE GANGLION

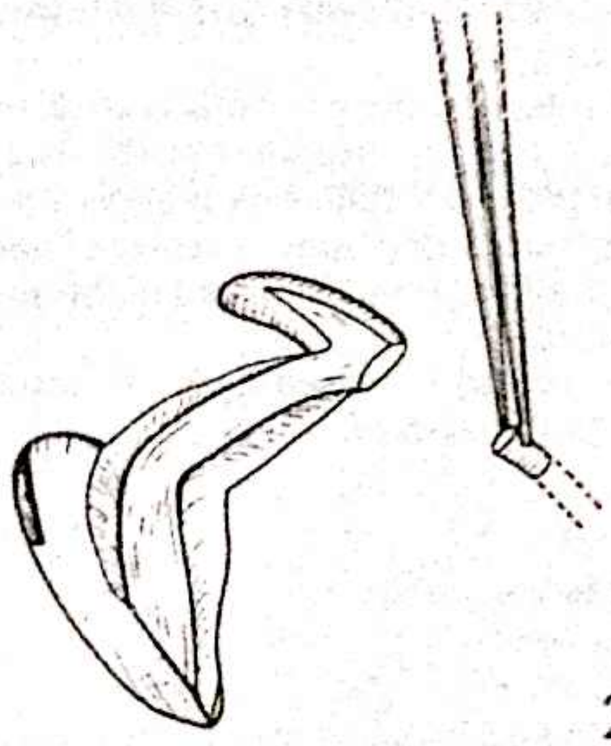
Excision of the ganglion is indicated for geniculate neuralgia resistant to conservative treatment. This condition is characterized by neuralgic ear ache accompanied by increased lacrimation and nasal secretion.

Poor general condition of the patient and psychological involvement are contraindications.

The labyrinthine and meatal segments of the facial nerve are exposed. After incision of the epineurium and meatal dural sac, the geniculate ganglion is excised together with a segment of the greater petrosal nerve. Accoding to anatomical measurements, 90 per cent of geniculate ganglion cells are situated in the anterior third of the external genu of the facial nerve (*a*). In order to avoid possible regeneration of nerve fibres a Silastic sheet is placed over the facial nerve and underneath the distal stump of the greater petrosal nerve (*b* and *c*).



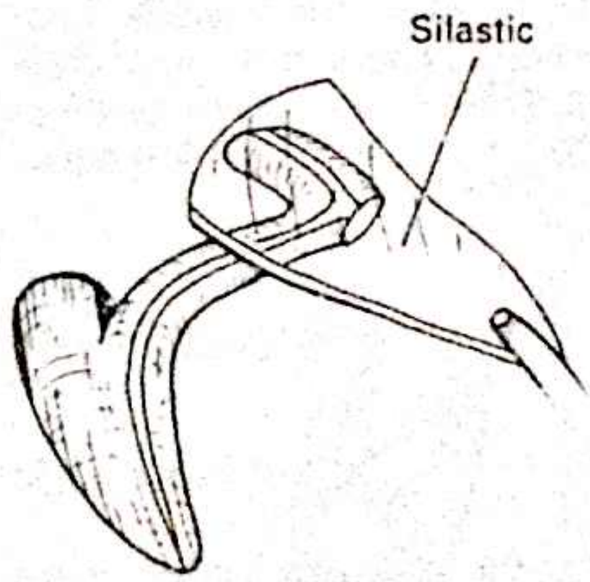
23a



23b

Complications

Delayed transitory facial palsy occurs in 10 per cent of cases. About 20 per cent of patients have a recurrence at the end of 2 years.



23c

24

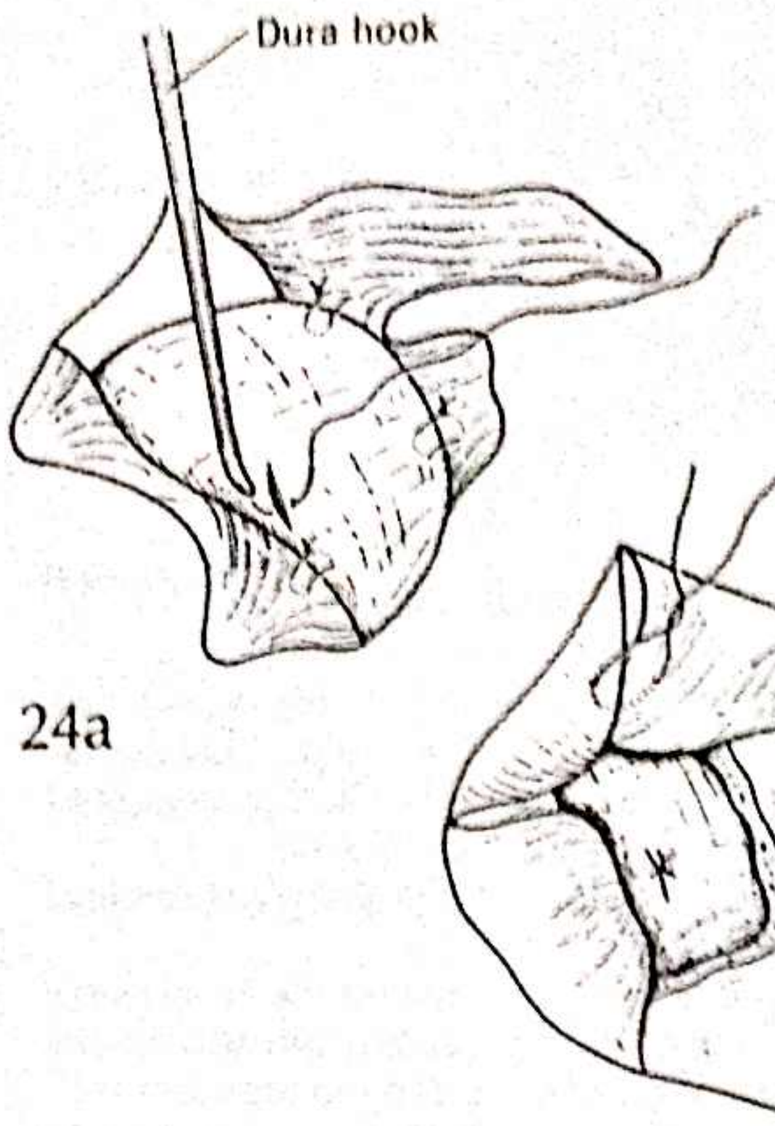
CLOSURE OF WOUND

The decompression incision is closed and the dura is attached to the temporalis muscle flaps with 4/0 atraumatic silk sutures (a) in order to avoid formation of an epidural haematoma.

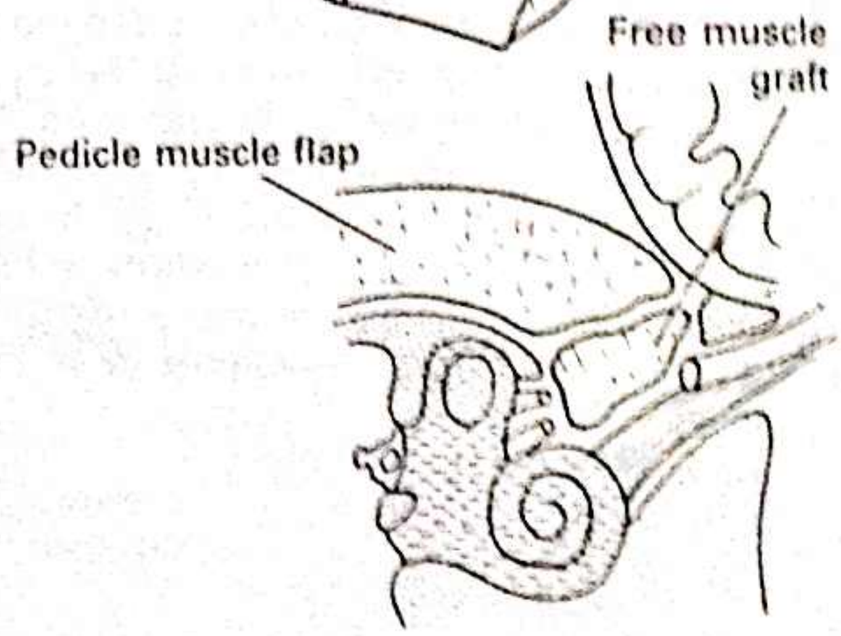
The internal auditory canal is covered with a free muscle graft (*b*) and the pedicle muscle flap is rotated over the meatal plane to obliterate the gap created in this area.

The craniotomy bone is replaced and a negative suction drain (Redon Drain) is placed in the anterior portion of the wound (*c*).

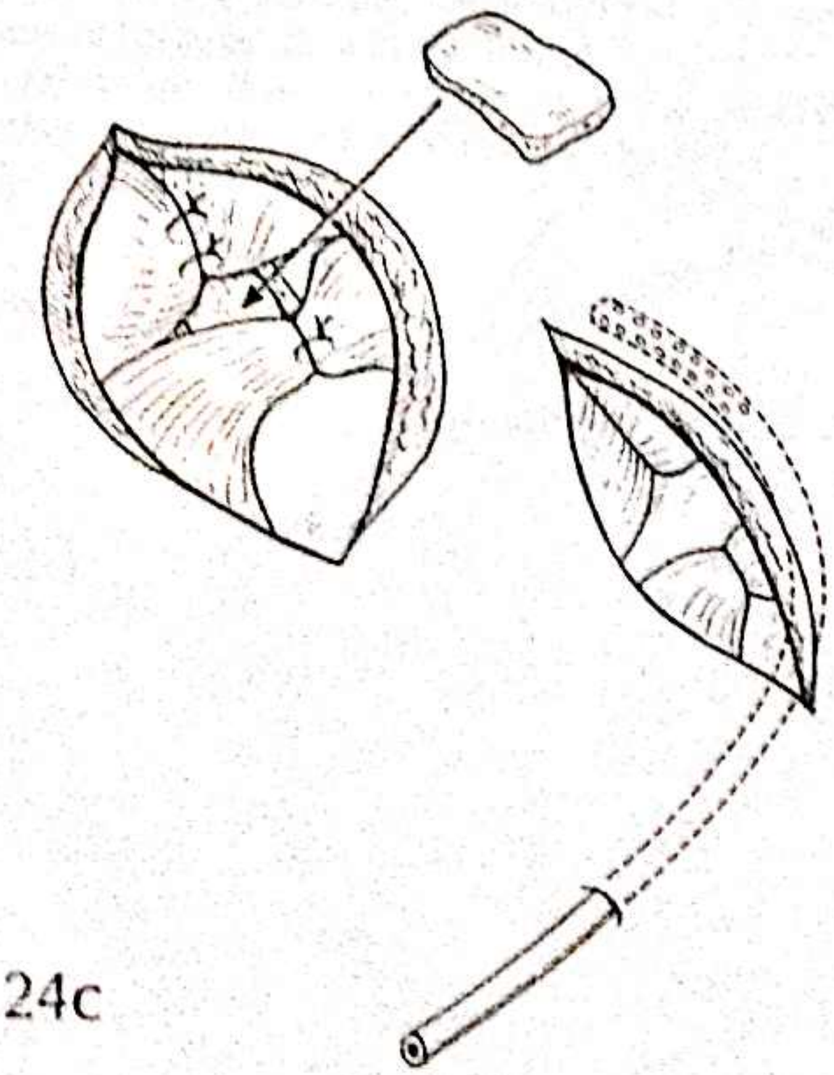
The wound is closed with silk sutures and the drain is fixed to the skin (*d*).



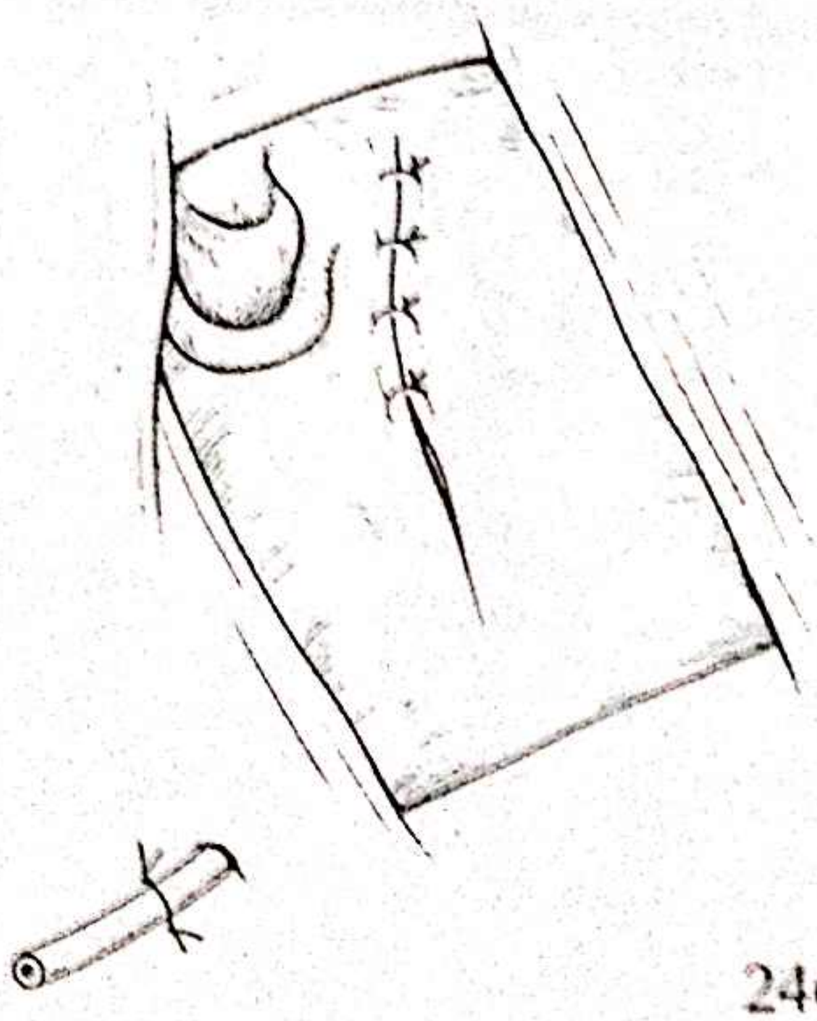
24a



24b



24c



24d

Illustrations by James Bruce

Infratemporal approach to the temporal bone, petrous apex and cerebellopontine angle

Malcolm D. Graham MD
Professor and Vice Chairman, Department of Otolaryngology – Head and Neck Surgery, University of Michigan Medical School, Ann Arbor, Michigan, USA

John L. Kemink MD
Assistant Professor, Department of Otolaryngology – Head and Neck Surgery, University of Michigan Medical School, Ann Arbor, Michigan, USA

Introduction

The infratemporal fossa approach provides wide surgical access to the lateral skull base. The introduction in recent years of this approach has enabled surgical exposure of the entire length of the infratemporal carotid artery, together with control of the venous sinuses adjacent to the temporal bone and mobilization of the infratemporal facial nerve[1,2].

Glomus jugulare tumours are now accessible to the skull base surgeon. Resection of the zygomatic arch and displacement or resection of the mandibular condyle anteriorly allow access to petrous apex, nasopharyngeal, retropharyngeal and parasellar lesions.

Surgical management of glomus tumours of the temporal bone requires accurate preoperative assessment, and a thorough knowledge of the temporal bone anatomy, contemporary microsurgical techniques and appropriate postoperative management. Care should be exercised to minimize postoperative neurological deficit and deformity resulting from surgery of this usually benign lesion. The primary preoperative goal is to determine the extent of the lesion. Although the history and physical examination are helpful, radiological delineation of the tumour is imperative. Recent advances in surgical approach and techniques have allowed the removal of large tumours with less morbidity and mortality. Our overall experience of glomus tumours leads us to believe that surgical excision is the treatment of choice.

Preoperative

Resectability

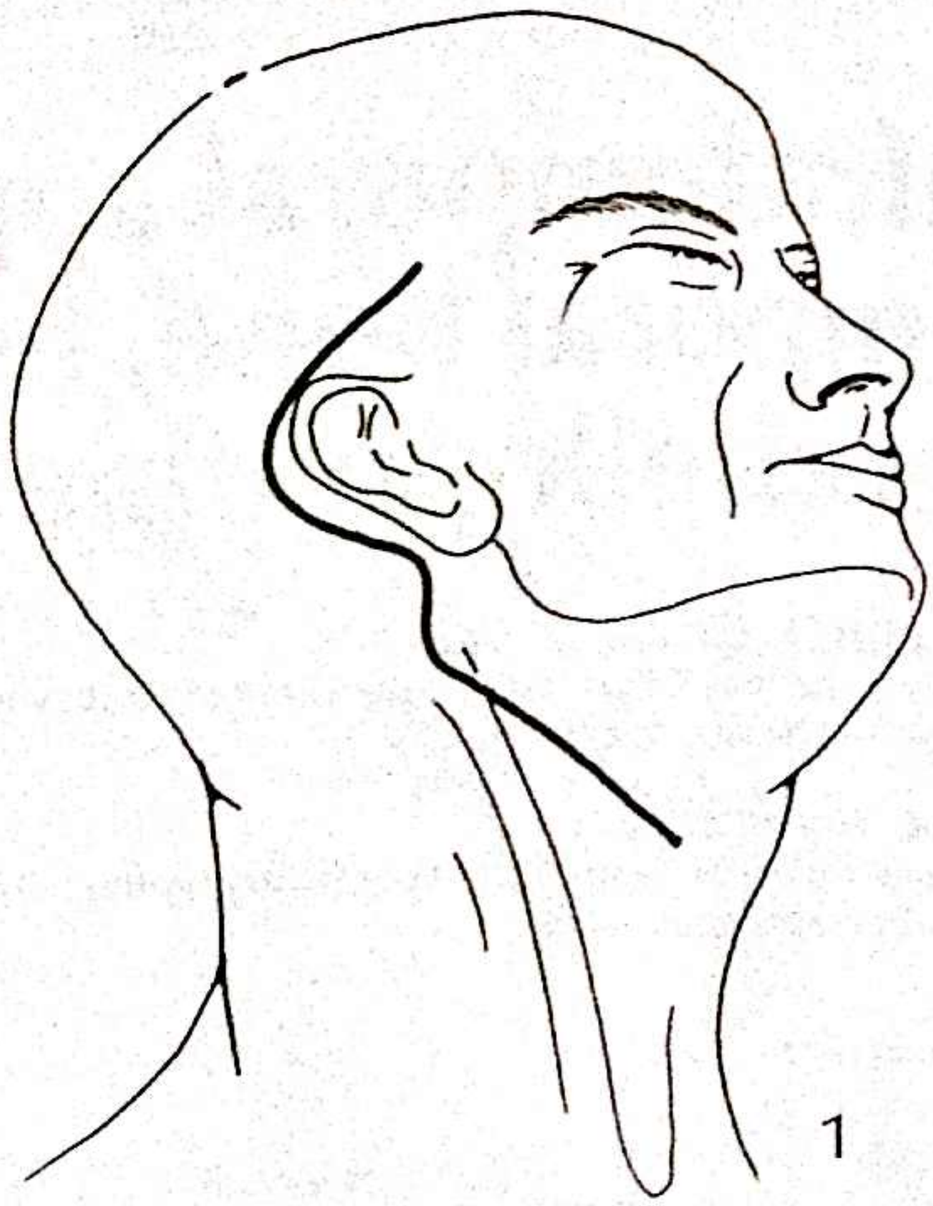
Resectability is usually determined preoperatively with available radiological techniques. At present we consider a lesion unresectable if there is significant involvement of the clivus, basilar artery or cavernous sinus.

The operation

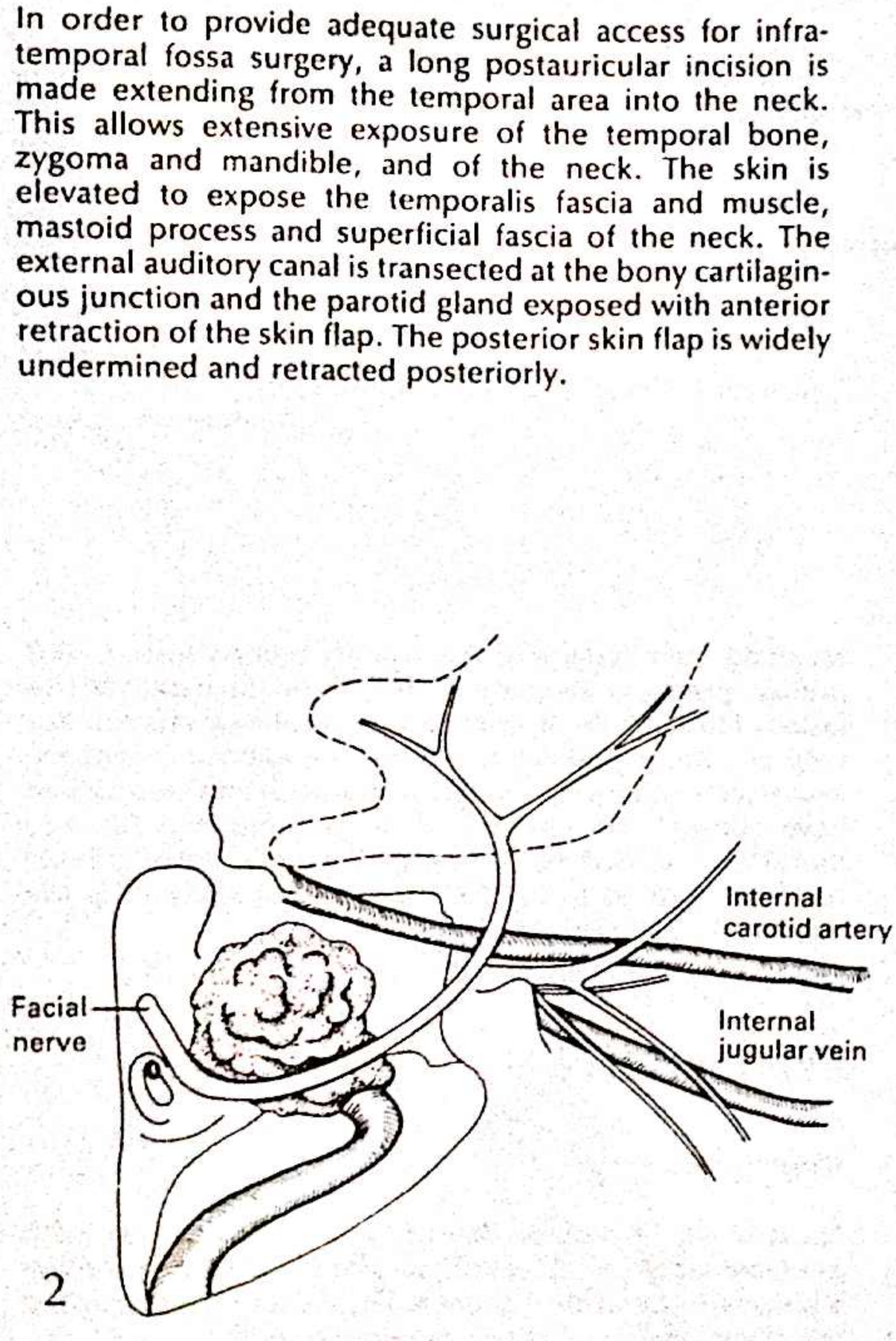
The skin incision

1

In order to provide adequate surgical access for infratemporal fossa surgery, a long postauricular incision is made extending from the temporal area into the neck. This allows extensive exposure of the temporal bone, zygoma and mandible, and of the neck. The skin is elevated to expose the temporalis fascia and muscle, mastoid process and superficial fascia of the neck. The external auditory canal is transected at the bony cartilaginous junction and the parotid gland exposed with anterior retraction of the skin flap. The posterior skin flap is widely undermined and retracted posteriorly.



1



2

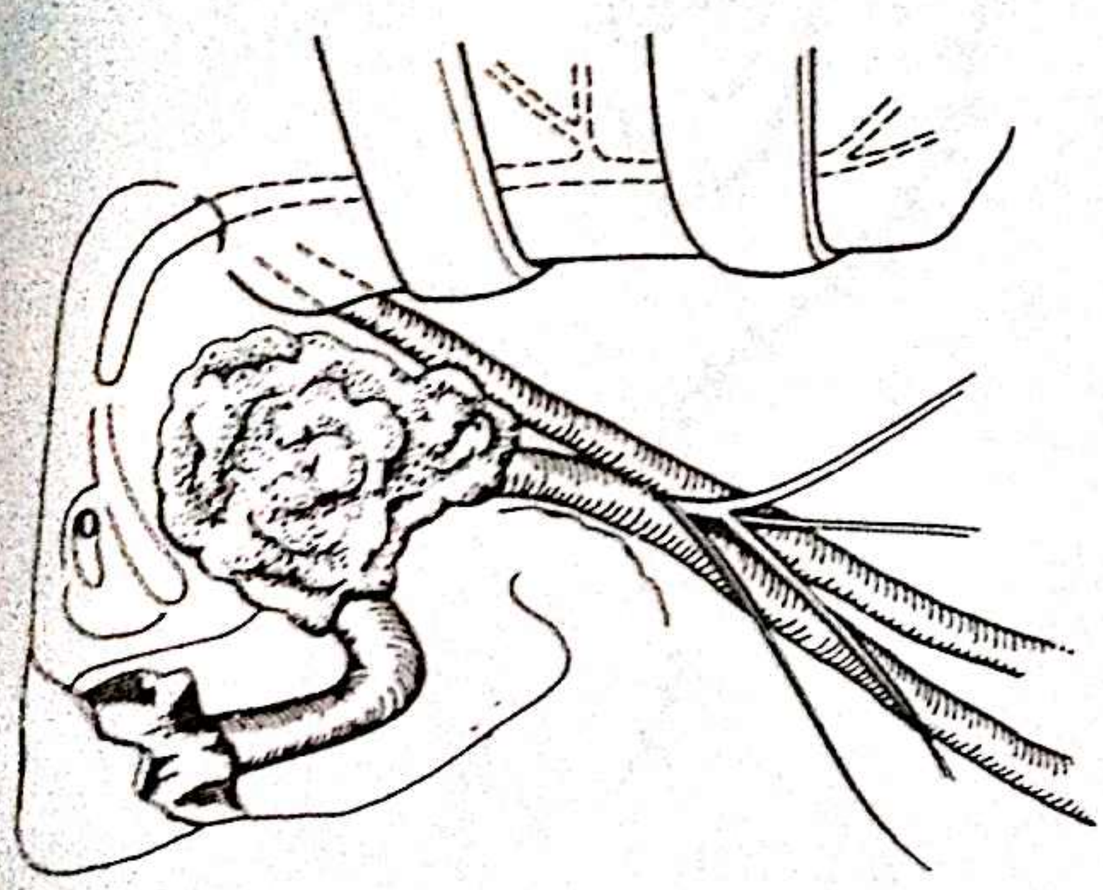
Neck dissection

2

The upper neck is dissected and the contents of the carotid sheath are identified. Vascular loops are used to control the internal jugular vein and the internal and external carotid arteries. Cranial nerves IX, X, XI and XII are identified and carefully preserved. The external carotid, occipital and ascending pharyngeal arteries may be doubly ligated. The cranial nerves and great vessels are dissected superiorly to the skull base, taking care to avoid the facial nerve as it exits the stylomastoid foramen.

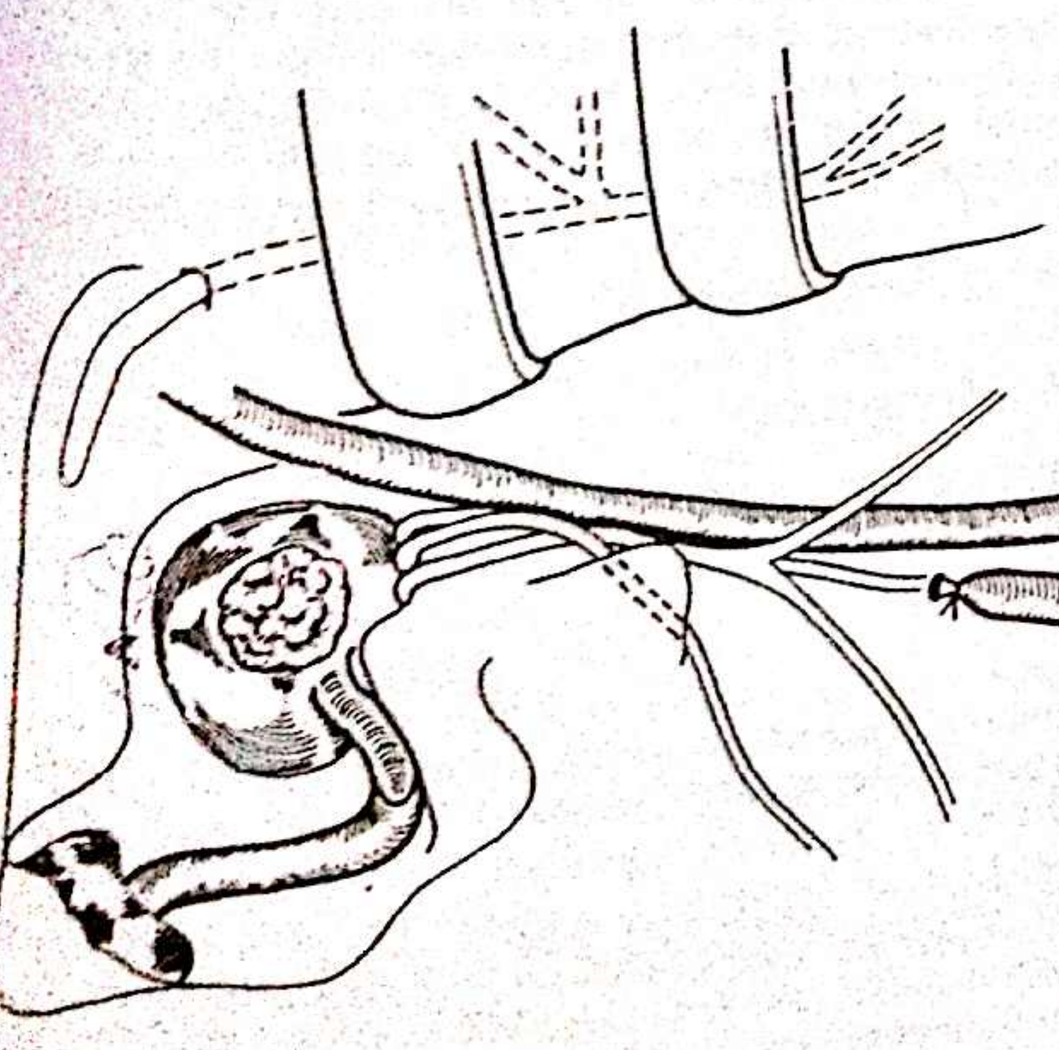
Lateral temporal bone dissection

The sternocleidomastoid muscle is dissected from the mastoid tip, care being taken not to injure the facial nerve. A radical mastoidectomy is then performed, skeletonizing the sigmoid sinus and removing the posterior bony external auditory canal. The malleus, incus, external auditory canal skin and tympanic membrane are removed. All deep external auditory canal skin must be carefully removed.



2

3



4

3

The facial nerve is exposed from the geniculate ganglion to the stylomastoid foramen. Bony decompression of 270° of the bony canal circumference is obtained whenever possible. The mastoid tip is 'eggshelled' from within and the digastric fascia exposed. In the posterior stylomastoid foramen the digastric fascia is incised posteriorly, thereby allowing freedom to elevate and displace the facial nerve anteriorly from the geniculate ganglion into the neck. The facial nerve is protected with moist packing before removing the remnants of the tympanic bone with a drill to expose the jugular bulb, internal jugular vein and carotid artery.

The sigmoid sinus is doubly ligated just distal to the previously encountered mastoid emmisary vein or may be packed extradurally.

The internal carotid artery is identified in its vertical course through the temporal bone and, if required, additional exposure of the carotid artery as it courses anteriorly in the petrous apex may be accomplished by anterior displacement of the mandibular condyle, or resection of the neck of the mandible or zygomatic arch. It may be necessary to section the facial nerve during this manoeuvre with re-anastomosis of the nerve upon completion of the operative procedure.

Tumour removal

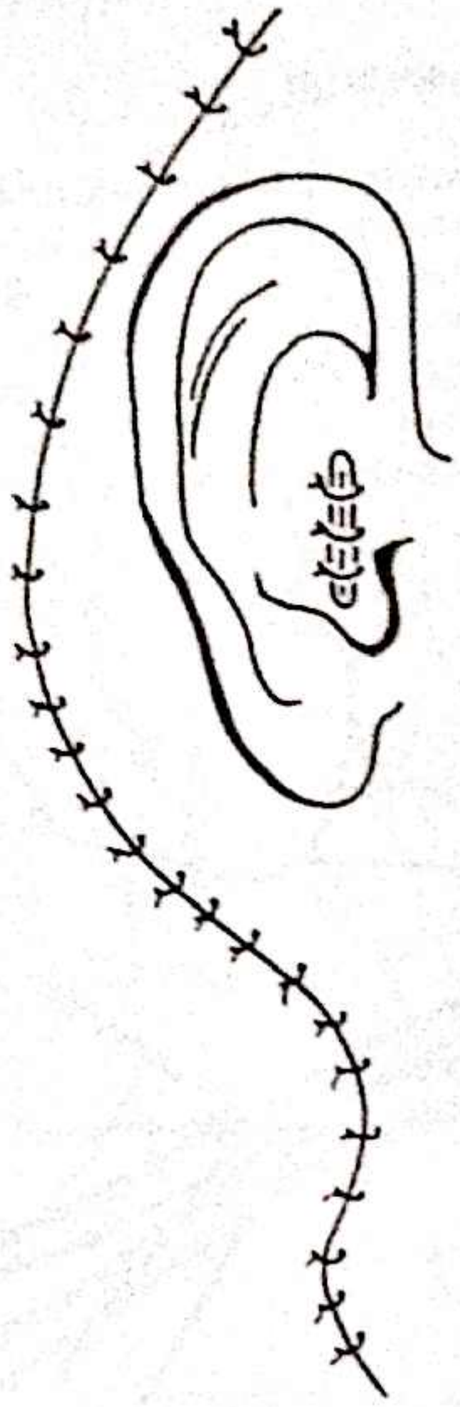
4

The internal jugular vein is doubly ligated in the neck and dissected superiorly to the skull base. The jugular vein and tumour are carefully dissected away from the medially positioned cranial nerves in the area of the jugular foramen, dissection and traction being exerted laterally to prevent unnecessary pressure on the cranial nerves. The lateral wall of the sigmoid sinus is then opened and the dissection continued progressively around the lesion. Tumour is carefully removed off the carotid artery with a combination of sharp and blunt dissection under the operating microscope. It should be appreciated that even in larger tumours the attachment of tumour is at the jugular bulb and not proximal or distal, although there may be tumour bolus within the lumen of the sigmoid sinus or internal jugular vein. When bleeding becomes profuse Surgicel is used to pack the bleeding site while attention is turned to another area. On removal of tumour from the jugular foramen the inferior petrosal sinus must be packed to control bleeding. Normally the tumour can be removed satisfactorily without cerebrospinal fluid leak. If, however, there is an intracranial tumour component (as shown), the tumour is sectioned in the plane of the posterior fossa dura and the base cauterized. The intracranial component may be removed in the same operation or at a later date.

Closure of external auditory canal

Closure of the cartilaginous external auditory canal is of vital importance, and must provide a water-tight seal if dura has been transgressed and cerebrospinal fluid leakage is to be prevented.

The skin and soft tissue of the lateral external auditory canal are elevated, everted and oversewn in layers with absorbable and permanent sutures (see *Illustration 5*). Adjacent soft tissue or a subcutaneous or periosteal flap is then used to reinforce the suture line.



5

Closure of neck incision

5

The cavity produced by removal of the tumour is obliterated with abdominal fat and the Eustachian tube is closed with fascia. The wound is closed in multiple layers and a wound drain inserted.

If an intracranial component has been removed, with resultant dural deficiency and thus the potential for cerebrospinal fluid leakage, the cavity is obliterated as above but, in addition, a lumbar cerebrospinal fluid drainage catheter may be inserted.

Complications

Bleeding

Bleeding is inevitable in the removal of these highly vascular tumours. Important basic requirements for the control of bleeding are expeditious surgical techniques and effective use of Surgicel packing and bipolar cautery. Complete removal of all bone lateral to the glomus tumour is essential before attempting actual tumour manipulation, so that the tumour removal process is unhampered and blood loss is minimized. Progressive sequential removal of tumour, with liberal use of packing, has contributed most significantly to our reduction of blood loss. We have not used preoperative embolization. Hypotensive anaesthesia and cryotherapy may also be considered as adjuncts for the control of haemorrhage.

Postoperative cranial nerve deficit

Postoperative deficits of adjacent cranial nerves (IX–XII) are sometimes inevitable following surgical removal of glomus jugulare tumours. Fortunately, if the cranial nerves are not sacrificed, many of these deficits will be temporary. Cranial nerve deficits are best avoided by meticulous dissection of the nerves under the operating microscope, leaving them intact medially in the jugular foramen. In some cases it may be possible to effect complete removal of the tumour while leaving a small area of the medial wall of the bulb, thereby avoiding exposure of cranial nerves IX, X and XI. The judicious use of tracheostomy and nasogastric feeding postoperatively can alleviate the significant complications that may result in patients with these paralyses.

Facial nerve management

Mobilization and transposition of the facial nerve and resection of the nerve with re-anastomosis or cable grafting have all been used. Although cranial nerve transposition may result in mild paresis, many patients have normal facial nerve function postoperatively. If tumour involvement requires resection of the facial nerve, transposition of the nerve may allow either direct anastomosis or, more commonly, cable grafting. If the facial paralysis or tumour involvement has been of long duration (more than one year), grafting will yield poor results and a static or dynamic facial plastic procedure may be preferable.

Acknowledgement

Illustrations 2–4 are modified from Fisch, Fagan and Valavanis[1].

References

1. Fisch, U., Fagan, P., Valavanis, A. The infratemporal fossa approach for the lateral skull base. Symposium on Skull Base Surgery. Otolaryngologic Clinics of North America 1984; 17: 513–552

2. Brammer, R. E., Graham, M. D., Kemink, J. L. Glomus tumours of the temporal bone: contemporary evaluation and therapy. Symposium on Skull Base Surgery. Otolaryngologic Clinics of North America 1984; 17: 499–512

Illustrations by Ed Zilberts

Cochlear implantation

Derald E. Brackmann MD
Clinical Professor of Otolaryngology, University of Southern California, Los Angeles, USA

Work on the cochlear implant as a means of restoring hearing to the deaf began at the House Ear Institute in 1960. Through the efforts of Dr William F. House and Mr Jack Urban, an engineer, an effective single-channel cochlear implant was developed and single-channel cochlear implantation is now a recognized clinical procedure. Over 200 of these operations have been performed at the Institute. The technique illustrated here was developed by Dr House.

Principles and justification

The normal cochlea acts as a transducer of the mechanical energy of sound vibration to a form of energy capable of stimulating the auditory nerve. This function is performed by the hair cells within the cochlea, and their absence results in total hearing loss. The cochlear implant attempts to replace the function of the lost hair cells by transforming the mechanical energy of sound into electrical energy which directly excites the remaining auditory neurons.

Only patients with remaining viable auditory neurons can benefit from this device. Fortunately, almost all patients with profound hearing impairment have at least a few such remaining neurons. Temporal bone studies of one of our patients have shown that only a few remaining auditory neurons are necessary to obtain benefit from this device[1].

Evaluation and selection of patients

Candidates for implantation are identified by careful medical, audiological and psychological testing. Medical evaluation includes a history and physical examination, electronystagmography, X-rays of the inner ear, and promontory response to electrical stimulation in order to assess grossly whether the patient has any remaining intact and functioning nerve fibres[2].

Audiological evaluation includes pure tone, speech and impedance audiometry to determine the degree of hearing impairment. The patient's ability to discriminate speech and environmental sounds with the aid of powerful hearing aids is also tested and compared to the performance of experienced cochlear implant users. Patients who score better with a hearing aid than is expected with the implant are advised to forego implantation and use a hearing aid.

Psychological evaluation includes interviews, standardized tests and questionnaires. Potential candidates should have no evidence of physiological brain damage, psychosis or mental retardation, and no unrealistic expectation of the implant. They should also have no personality traits that would decrease the probability of successful participation in the implant program.

However, the final decision regarding implantation rests with the patient, who must decide whether he is willing to undergo the surgical procedure, to wear a rather large and bulky instrument and to spend time learning how to interpret what will not be normal auditory sensations. Every effort is made to ensure that the patient understands the limitations of the implant. The patients should be given the opportunity to ask questions, to discuss with staff the advantages and disadvantages in relation to their own needs, and to interview an experienced implant user.

Preoperative

Preparation

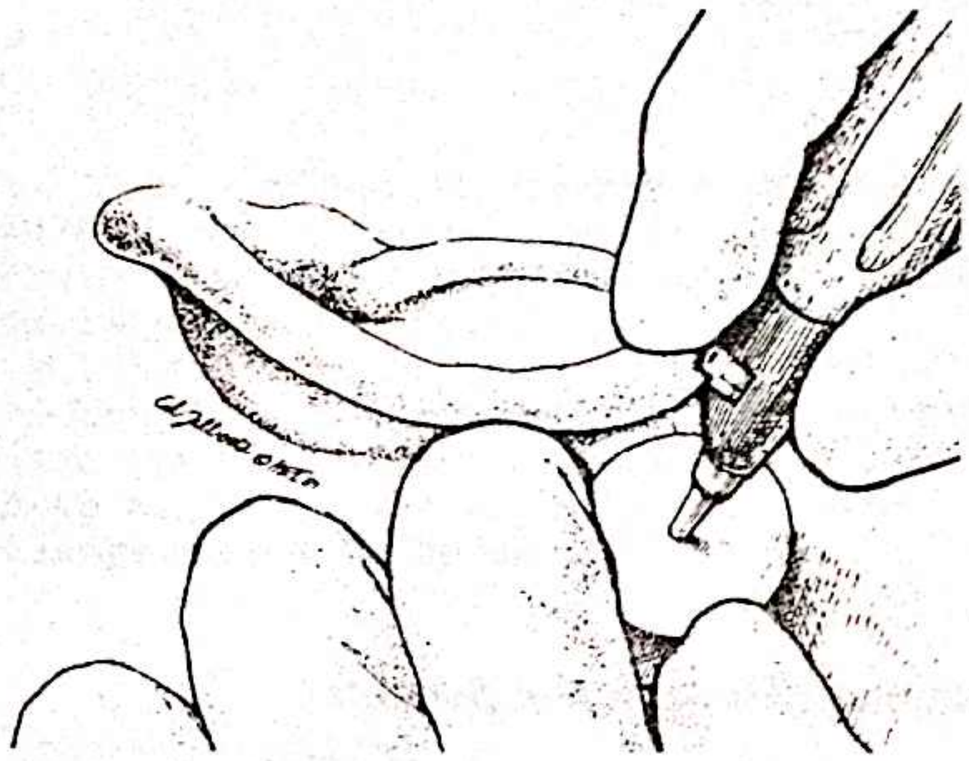
The postauricular region is prepared by removing the hair around the ear to approximately 7.5 cm. Plastic drapes are attached with adhesive.

Immediately before the operation the ear and postauricular area are cleansed with iodine solution and sterile drapes are applied as for a mastoid procedure. Preoperative antibiotics are not used.

Anaesthesia

The operation is carried out under general endotracheal anaesthesia. Hypotensive anaesthesia is not required.

The operation



1

1

The external coil should lie above and behind the pinna. In order to mark its position a dummy coil the size and shape of the external coil is placed on the skin before distortion of the tissue with local anaesthetic. The external coil should be as close to the pinna as possible without touching it, as close contact could cause a pressure sore later on. The position of the internal coil, which must be directly under the external coil, is marked by pushing a slender, sharp drill through the centre of the dummy coil and drilling a small hole into the squamous portion of the temporal bone.

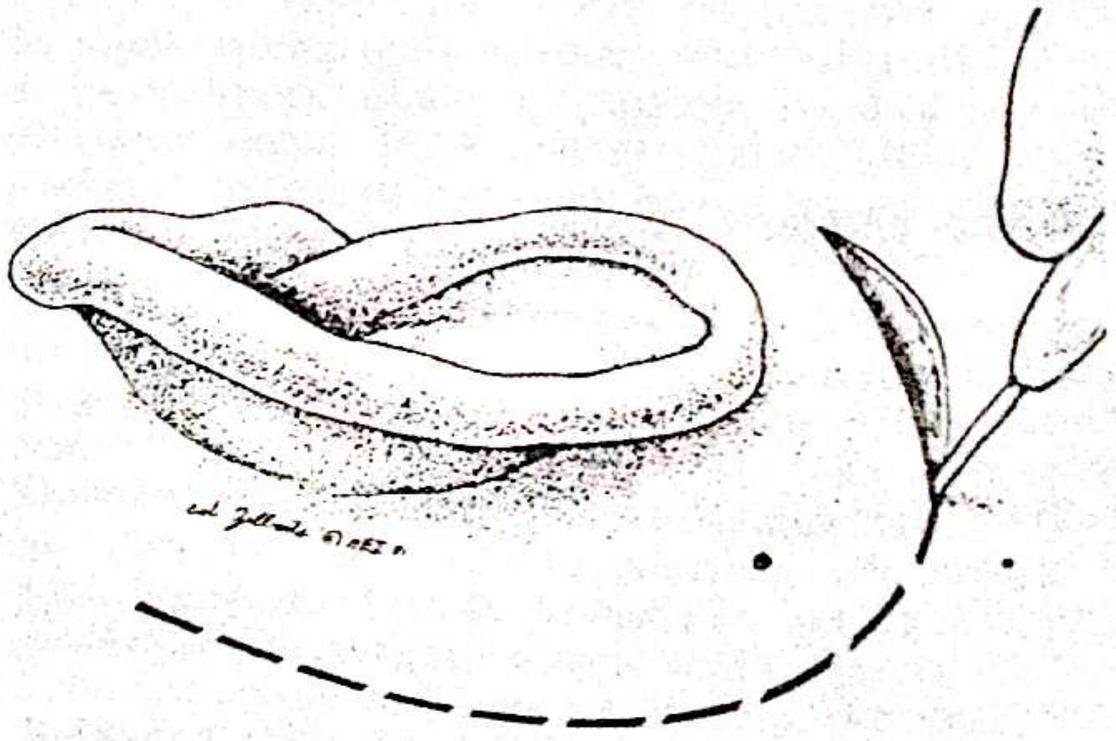
2

The incision

The postauricular scalp is infiltrated with lignocaine (lidocaine; Xylocaine) in 1:100 000 adrenaline (epinephrine) and a large postauricular incision is made. This is kept 1 cm behind the edge of the internal coil in order to minimize damage to the superficial temporal vessel supplying the skin of the area. The lower pole of the incision should not be carried too far into the postauricular crease since this may damage the branches of the occipital artery that also supply the postauricular scalp.

The postauricular flap is elevated forward. The avascular plane between the scalp and the temporalis muscle is developed, and the periosteum over the mastoid below the linea temporalis is incised and then elevated using a Lempert periosteal elevator. The flap is developed further and the spine of Henley identified. Care must be taken not to cut between the periosteum and the scalp as this diminishes the blood supply to the flap and does not improve surgical access.

Retractors are placed and a large piece of temporalis muscle is removed under the squamous portion of the temporal bone. This allows better seating of the internal coil and has the added advantage that the scalp heals against the bone around the internal coil, making it easier to palpate and reducing the thickness of the scalp over it.

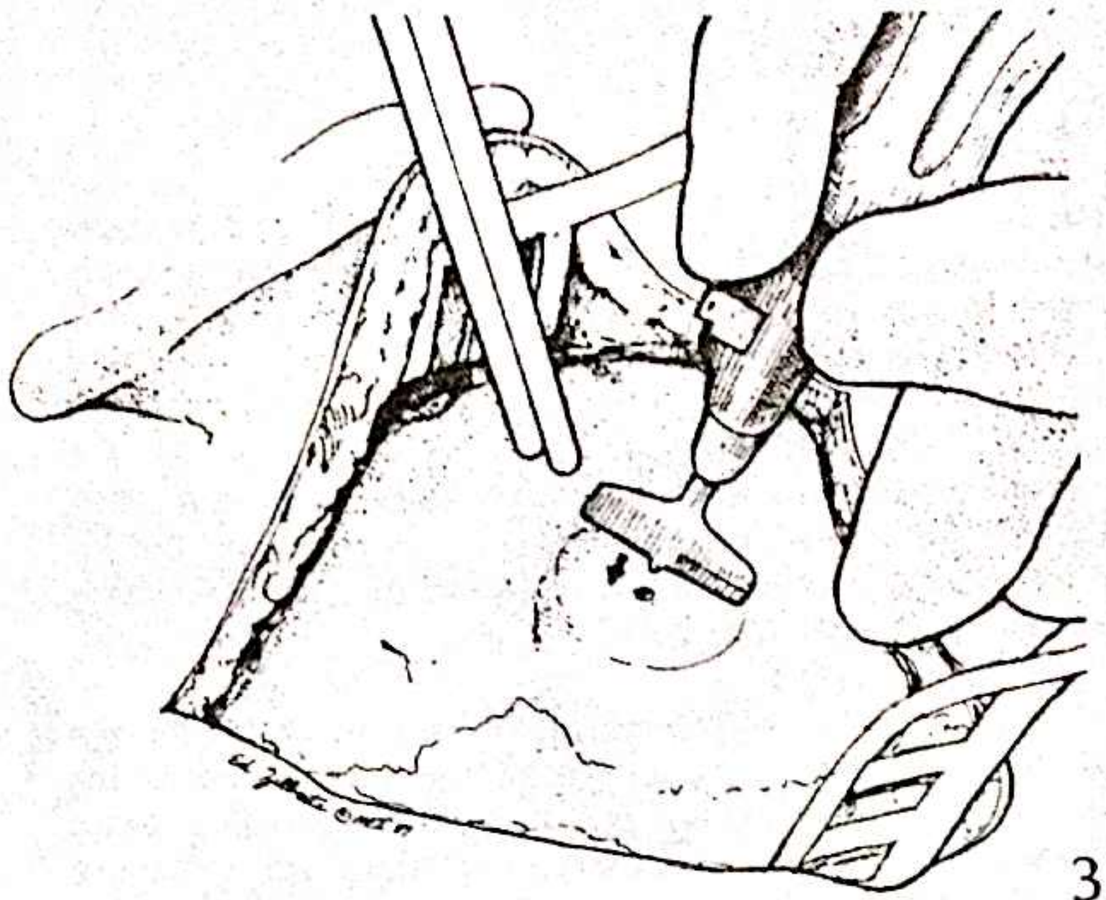


2

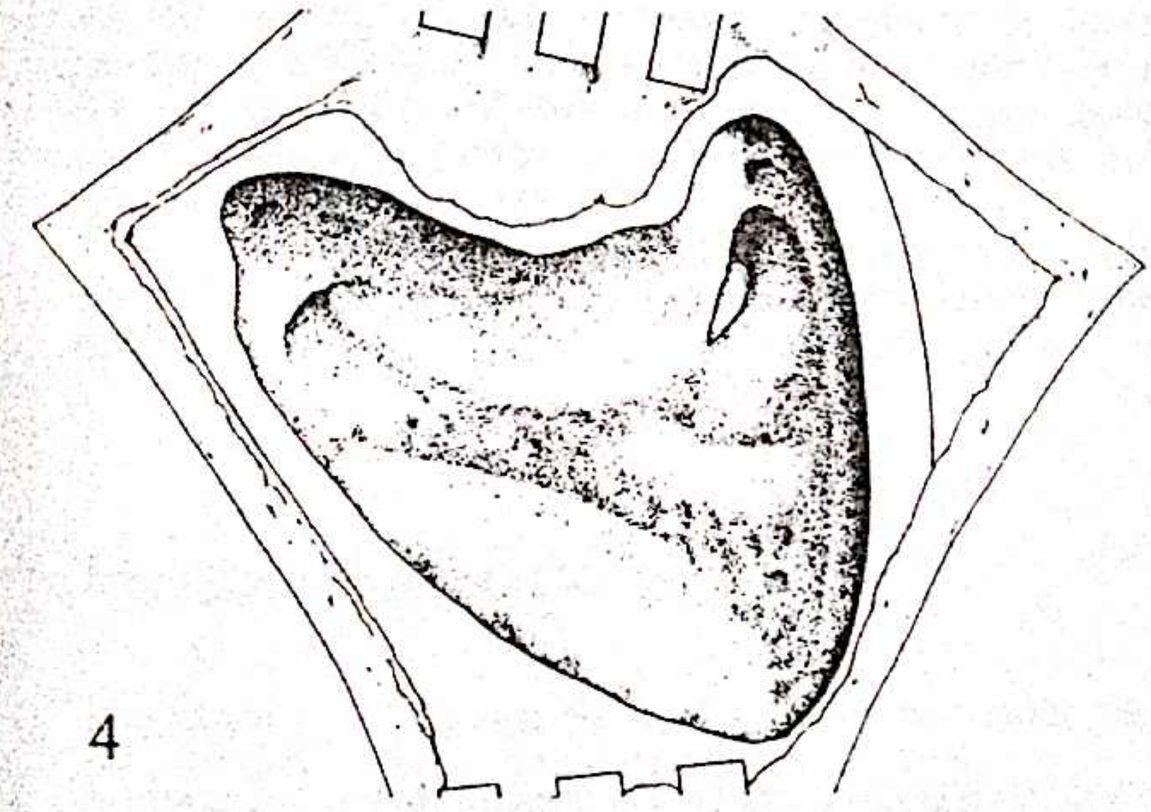
3

Seating the internal coil

Removing the muscle also brings into view the small drill hole made through the centre of the external dummy coil at the beginning of the operation. This hole is enlarged and deepened (to 4 mm in adults) with a special drill which has a guard to prevent penetration through the bone into the underlying dura and brain. Using a reamer (butterfly burr) the same size as the internal coil, a seat is made in the bone to accept the internal coil and locate it properly on the bone. It also helps to keep the coil from shifting out of place during the healing period. Its plane must be angled so that the internal coil comes to lie parallel to the scalp surface.



3

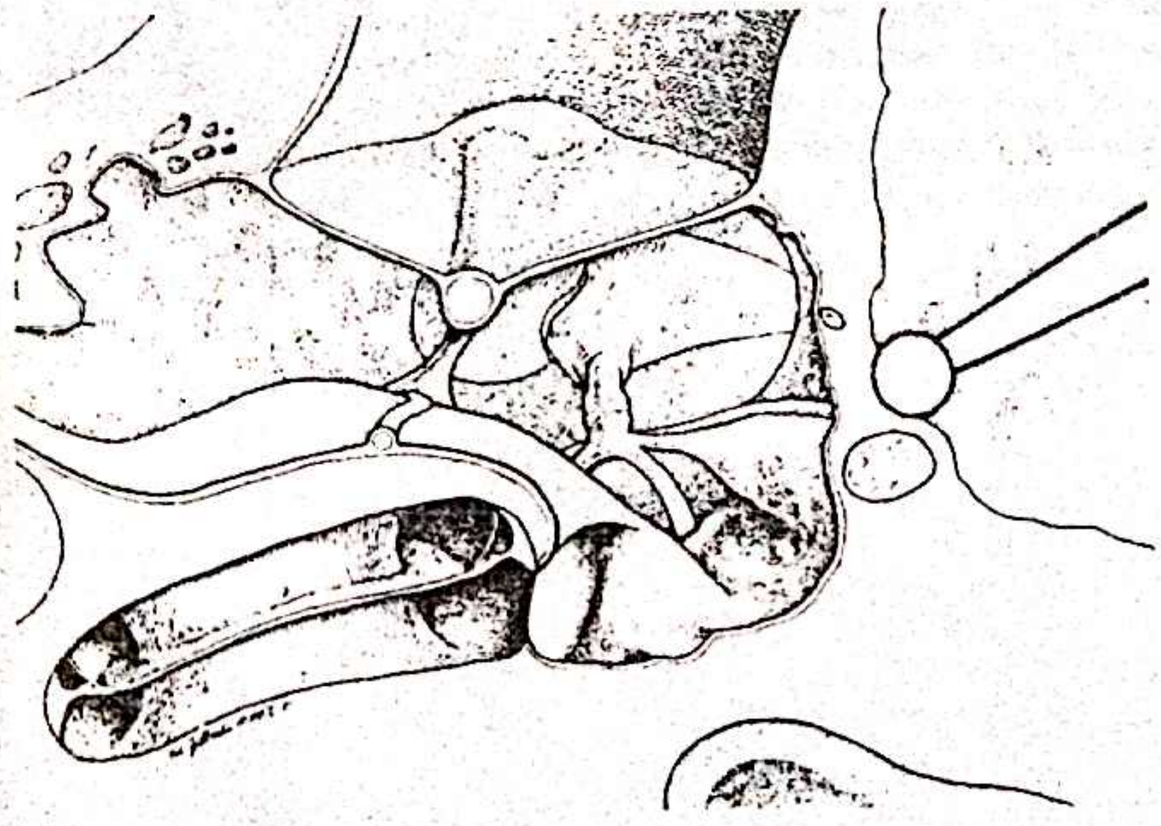


4

Mastoidectomy

4

A complete simple mastoidectomy is then carried out using conventional cutting burrs and continuous suction irrigation. Bone removal extends posteriorly to the sigmoid sinus. Collapse of the sigmoid sinus is not necessary unless it is unusually far forward. The middle fossa plate is skeletonized and the antrum and horizontal semicircular canal are identified. Sufficient bone is removed in the attic area to allow a clear view of the top of the incus. The incus or other ossicles are not disturbed. The posterior bony canal wall is now thinned, taking care not to fenestrate the bone of the external auditory canal. This thinning is an essential step in opening of the facial recess.



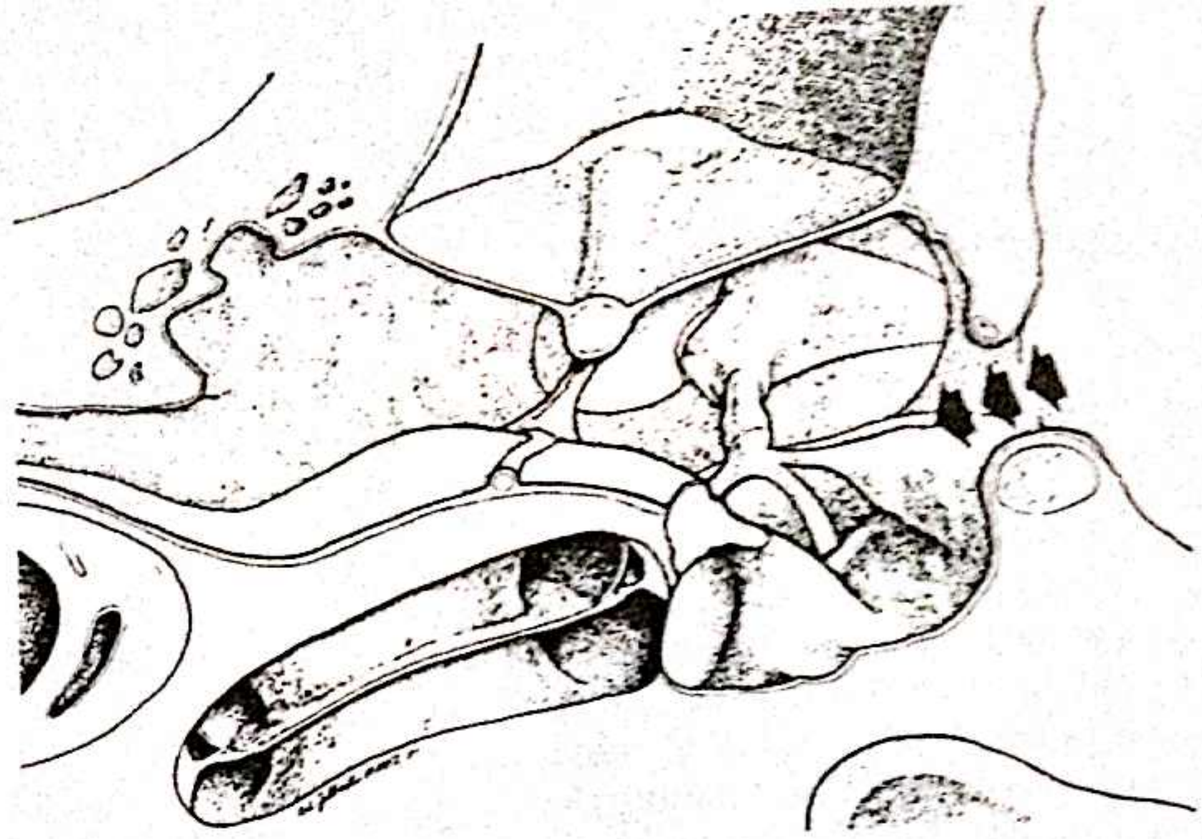
5

5

Using progressively smaller cutting burrs and profuse irrigation, bone is gradually removed along the facial nerve until the air cell track representing the facial recess is identified. The facial nerve is skeletonized at the second genu but the nerve sheath itself should not be exposed. The inferior lateral limit of the facial recess, the chorda tympani nerve, is identified. Following the chorda tympani forward leads to the tympanic annulus.

6

The facial recess is then entered with a small diamond burr and enlarged until the round window niche can be easily seen. In some cases, if the facial recess is restricted, it is necessary to remove the chorda tympani nerve and extend the facial recess inferiorly through this area. The lip of the round window is now usually visible just below the stapedius tendon and head of the stapes. Using a small diamond burr and intermittent suction-irrigation, the lip of the round window is removed and the round window membrane comes into clear view.



6

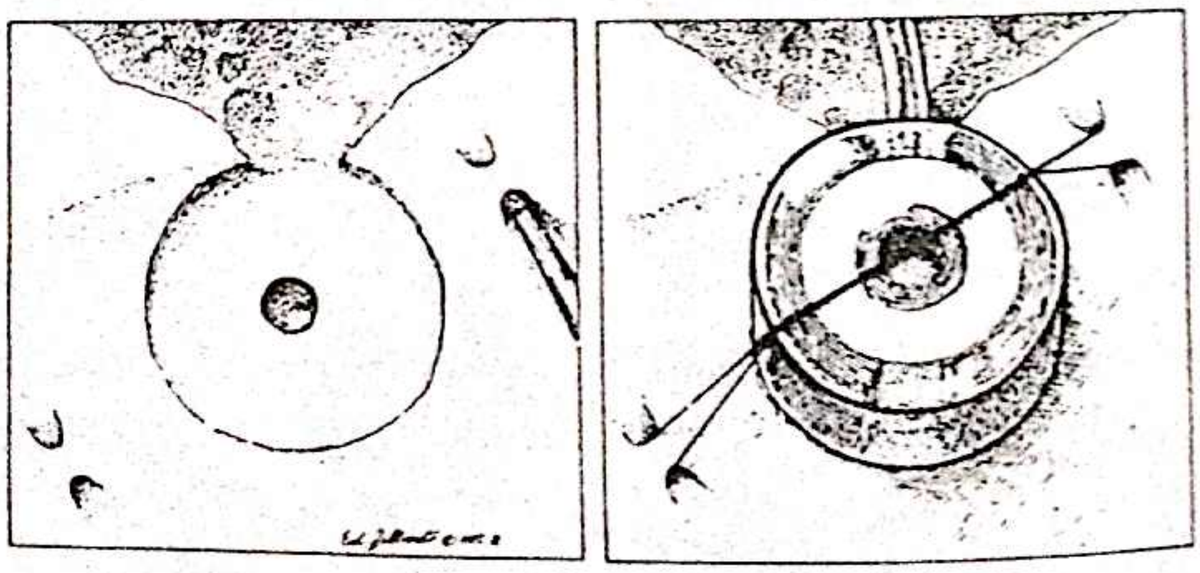
With a smaller diamond stone and small hooks, an opening large enough to accept the ball of the active electrode is made just in front of the annulus of the round window membrane. It is extremely important to ensure that the diamond stone is not rotating when passing through the facial recess to the round window area as this increases the risk of injury to the facial nerve.

Occasionally the round window niche is almost hidden under the pyramidal process. In this case drilling must proceed in a forward direction, thinning the promontory until the scala tympani is entered. In some cases of obliterative otosclerosis or labyrinthitis ossificans the round window niche and membrane have been replaced by new bone growth. Careful preoperative study of polytome X-rays should warn of this problem and allow the surgeon to determine how far forward on the basal coil the opening will be made. In some cases this may be as much as 5 or 6 mm. Usually the new bone growth is whiter and can thus be demarcated from the surrounding otic capsule. Following this white plug of bone with the drill eventually leads to the patent scala, in which an opening is made to accept the active electrode.

Electrode insertion

7a & b

A small tunnel is made in the bone with a diamond burr on each side of the proposed site of the internal coil (*a*). The internal coil is removed from its sterile packing and placed into the bony seat and sutured in place (*b*).



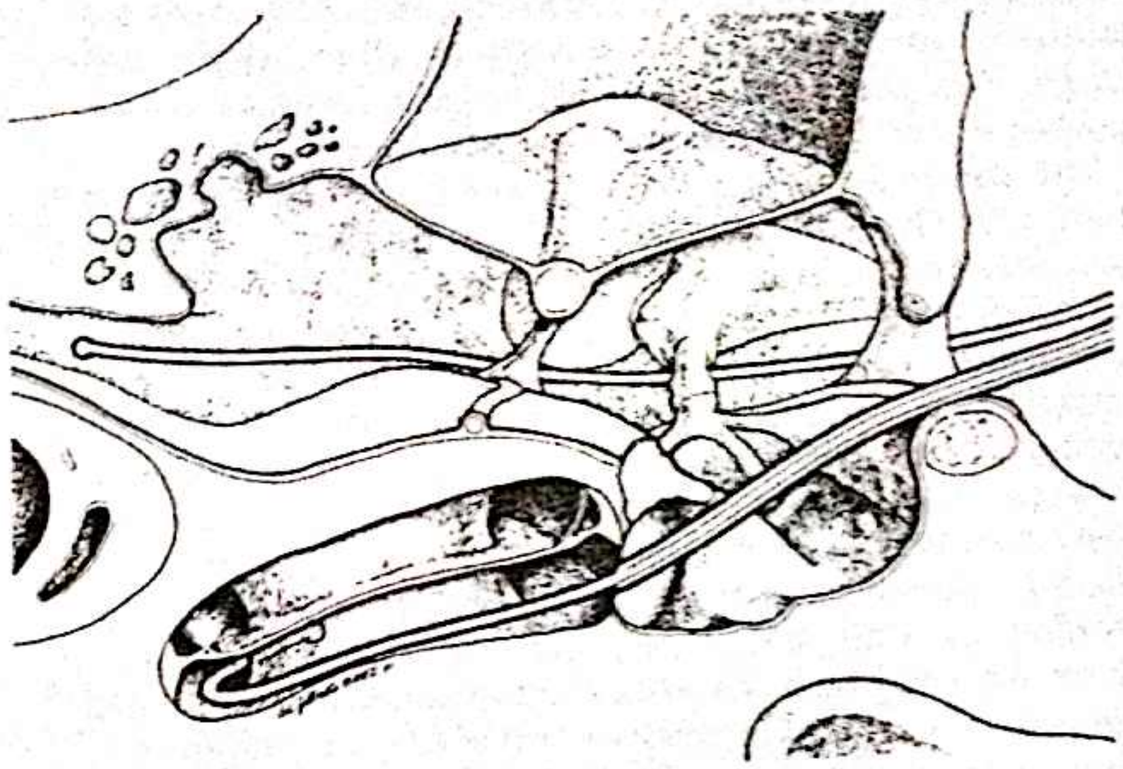
7a 7b

8

Once the coil has been secured, the ground electrode, which is an exposed platinum wire, is placed into the attic behind the tensor tendon and then down into the protympanum. The active electrode, which has a 0.5 mm ball on the end and 6 mm of exposed wire beyond the silicone rubber insulation, is inserted into the opening made in the scala tympani. To minimize damage to the basilar membrane the electrode is pushed in such a way that it follows the outer curve of the scala tympani. This is done under direct vision, advancing the electrode in the direction of the patient's nose (downward and forward). The entire exposed metal electrode should come to lie in the scala tympani, with the edge of the insulation at the round window membrane. Fascia is packed around the active electrode at the round window.

Once the electrodes have been placed, it may be hazardous to use conventional cautery in which the current flows from the active electrode of the cautery through the body to the ground electrode (usually placed on the patient's back) choosing the path of least resistance. With the electrodes in place this could be via the active or ground electrode. For this reason only bipolar cautery is used to control skin bleeding after the electrodes have been placed.

The skin is closed by subcuticular sutures of absorbable material. Care is taken not to damage the insulation of the coil with the needle.



8

Postoperative care

The wound is allowed to heal for approximately two months before the external stimulator is fitted.

The external device consists of a microphone which is worn at ear level in a conchal mould. The signal received by this microphone is fed into the external stimulator. Amplitude modulation of a 16 kHz carrier frequency is produced and delivered to the external coil. The external coil is held over the internal coil by eye glasses, a head band or, in some cases, by magnets placed inside the internal and external coils. This creates an electrical field in the internal coil. The electrodes are stimulated, thereby producing an electrical field around the remaining auditory neurons.

Postoperative complications

There are remarkably few postoperative complications and there have been no cases of meningitis, cerebrospinal fluid leak, middle ear infection, persistent unsteadiness, vertigo, facial nerve spasm or facial paralysis. There have also been no adverse neurological or psychological effects.

To date there have been two failures of primary wound healing over the implanted coil. One of these was corrected by revision of the skin flap. In the other it was necessary to remove the coil, leaving the electrodes in place. Replacement is planned after wound healing. One patient had a persistent perilymph leak, which healed when the electrode was removed. This patient has subsequently had a successful implant in the other ear. Postoperative antibiotics are not prescribed. Patients are discharged from hospital 24 to 48 hours postoperatively. Mild unsteadiness may continue for a few days. Vertigo or significant balance disturbance has not occurred.

Results

The implant enables the patient to detect a broad range of frequencies (approximately 200 to 7000 Hz). Responses are primarily to intensity and durational clues within this range. The perception of frequencies is confined to the lower-pitched components of the above-audio range[3].

The major limitation of the present implant system is that speech understanding is not possible through audition alone. Nevertheless, subjective descriptions of sound processed through the implant system are generally positive. Users can recognize a variety of environmental sounds and, with training, can identify many of them in context. They tend to feel safer driving their cars because they can hear sirens, horns and other warning sounds. They can also use the telephone for coded conversations. Sound transduced by the implant complements lip reading by adding low frequency information to visual clues. An additional advantage is that patients can monitor their own voices and thus improve speech production. They can distinguish different categories of music, environmental sounds and speech, and differentiate sounds occurring simultaneously. They also report improved perception of sounds at a distance. Many sounds are perceived at a comfortable listening level.

The quality of sound is often described as 'mechanical, tinny, metallic, distorted and muffled'. Comparison to an 'untuned' or 'off-station' radio, where differences between speech and music can be heard but not understood, is also common. Appreciation and enjoyment of music seems to be enhanced.

Most patients regard the auditory information provided by the cochlear implant as so beneficial that they use the device all day and every day. They tend to worry less about their safety, and to feel less isolated. As communication becomes less difficult and less frustrating, social confidence increases and relationships with their families often become more satisfying and they feel less of a burden. As a result the quality of life of the patient's relatives also often improves.

Revision implant surgery

The cochlear implant may fail because of shorting of the internal coil. Revision surgery is performed under local anaesthesia. The postauricular incision is opened and the postauricular skin flap developed along the plane of the coil and electrodes. The electrodes are isolated and cut, leaving both the ground and active electrode in position. The new coil is then seated and secured by suture. The two ends of the electrodes are placed within a platinum tube which is crimped over both ends of the electrodes. Melted bone wax is used to cover the exposed connection to provide insulation.

Acknowledgements

The author is indebted to Elaine M. Kalivoda of the House Ear Institute for preparation of the manuscript.

The research leading to this chapter was sponsored by a grant from the House Ear Institute, an affiliate of the University of Southern California School of Medicine, Los Angeles, USA.

References

1. Johnsson, L.-G., House, W. F., Linthicum, F. L. Jr. Otopathological findings in a patient with bilateral cochlear implants. Annals of Otology, Rhinology and Laryngology 1982; 91 (Suppl. 91): 74–89

2. House, W. F., Brackmann, D. E. Electrical promontory testing in differential diagnosis of sensorineural hearing impairment. Laryngoscope 1974: 84: 2163–2171

3. House, W. F., Berliner, K. I., eds. Cochlear implants: progress and perspectives. Annals of Otology, Rhinology and Laryngology 1982; 91 (Suppl. 92): 1–124

Further reading

Eddington, D. F., Dobelle, W. H., Brackmann, D. E., Mladejovsky, M. G., Parkin, J. L. Auditory prosthesis research with multiple-channel intracochlear stimulation in man. Annals of Otology, Rhinology and Laryngology 1978; 87 (Suppl. 53): 1–39

Eddington, D. K. Multiple-channel intracochlear stimulation. In Brackmann, D. E., ed. Neurological surgery of the ear and skull base. New York: Raven Press, 1982, 199–205

Index